PROGRAM MANAGER FOR ROCKY MOUNTAIN ARSENAL

U.S. ARMY
MATERIEL COMMAND

— COMMITTED TO PROTECTION OF THE ENVIRONMENT —

FINAL
COMPREHENSIVE AIR QUALITY AND
METEOROLOGICAL MONITORING PROGRAM
AIR QUALITY DATA ASSESSMENT REPORT
FOR FY 1993
VOLUME II of IV

VERSION 2.0

OCTOBER, 1994
CONTRACT NO. DAAA05-92-D-0002
TASK ORDER 92.10

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13. ABSTRACT *(Maximum 200 words)*

THE PURPOSE OF THE COMPREHENSIVE MONITORING AIR QUALITY AND METEOROLOGICAL MONITORING PROGRAM (CAQMMP) AT RMA IS TO CONTINUE THE ONGOING COLLECTION OF BASELINE DATA THAT WAS ESTABLISHED UNDER THE REMEDIAL INVESTIGATION (RI) PROGRAM AND THE COMPREHENSIVE MONITORING PROGRAM (CMP). TOGETHER, THESE PROGRAMS ARE USED TO DETERMINE AMBIENT AIR QUALITY IN SUPPORT OF REMEDIAL ACTIONS BEING CONDUCTED AT RMA. THIS REPORT FOCUSES ON RESULTS OF THE CAQMMP FOR FISCAL YEAR 1993 (FY93) AND INCLUDES ANALYSES AND COMPARISONS TO DATA FOR PRECEDING MONITORING PROGRAMS AT RMA AND FOR OTHER PROGRAMS THAT RAN CONCURRENTLY. THE CAQMMP FY93 DATA, IN CONJUNCTION WITH PREVIOUS CMP/CAQMMP DATA, BASIN F REMEDIAL MONITORING PROGRAM DATA, AND BASIN F POST REMEDIAL IRA F MONITORING PROGRAM DATA, PROVIDE A COMPREHENSIVE DATABASE FOR EVALUATING REMEDIAL PROGRESS RESULTING FROM THE BASIN F CLEANUP PROGRAM AND OTHER REMEDIAL ACTIVITIES. ONE OBJECTIVE OF THIS REPORT IS TO PROVIDE AN ASSESSMENT OF THE COMBINED DATABASE IN THE CONTEXT OF REMEDIAL PROGRESS. DATA ANALYSES CHARACTERIZED POTENTIAL SOURCES

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LIST OF ACRONYMS AND ABBREVIATIONS

AA	Atomic Absorption
ACGIH	American Council of Governmental Industrial Hygienists
ADI	Acceptable Daily Intake
Army	U.S. Army
As	Arsenic
Atrazine	2-chloro-4-ethylamino-6-isopropylamino-s-trianine
BCHPD	Bicycloheptadiene
BLDG	Building
°C	Degrees Celsius
C_6H_6	Benzene
CAQMMP	Comprehensive Air Quality and Meteorological Monitoring Program
CCl_4	Carbon Tetrachloride
ccm	cubic centimeters per minute
CDH	Colorado Department of Health
cfm	cubic feet per minute
CFR	Code of Federal Regulation
CH_2Cl_2	Methylene Chloride
$CHCl_3$	Chloroform
Chlordane	1,2,4,5,6,7,8,8-Octachloro-2,3,3a,4,7,7a-hexahydro-4,7-methano-1H-indene
ClC_6H_5	Chlorobenzene
CMP	Comprehensive Monitoring Program
CMP FY90	Comprehensive Monitoring Program Fiscal Year 1990
CO	Carbon Monoxide
CRL	Certified Reporting Limit
CVAAS	Cold Vapor Atomic Absorption Spectroscopy
DBCP	Dibromochloropropane
11DCLE	1,1-Dichloroethane
12DCLE	1,2-Dichloroethane
12DCE	trans-1,2-Dichloroethene
DCPD	Dicyclopentadiene
DIMP	Diisopropylmethyl phosphonate
12DMB	1,2-Dimethylbenzene
DMDS	Dimethyldisulfide
DMMP	Dimethylmethylphosphonate
DPS	Denver Public Schools
EA	Endangerment Assessment
EBASCO	Ebasco Services Incorporated
EPA	Environmental Protection Agency
ESH	Effective Stack Height
ETC_6H_5	Ethylbenzene

LIST OF ACRONYMS AND ABBREVIATIONS (Cont.)

°F	Degrees Fahrenheit
FID	Flame Ionization Detector
FS	Feasibility Study
FY	Fiscal Year
GC	Gas Chromatograph
GC/MS	Gas Chromatography/Mass Spectrometry
GC/ECD	Gas Chromatography/Electron Capture Detection
GT	Greater Than
H_2S	Hydrogen Sulfide
HEAST	Health Effects Assessment Summary Table
Hg	Mercury
ICAP	Inductively Coupled Argon Plasma
IRA	Interim Reponse Action
IRA-F	Interim Response Action at Basin F
IRDMIS	Installation Restoration Data Management Information System
IRIS	Integrated Risk Information System
ISC	Industrial Source Complex Dispersion Model
lpm	liters per minute
m	meter
Malathion	S-[1,2-bis(ethoxycarbonyl)ethyl]0,0-dimethyl-phosphorodithioate
MEC_6H_5	Toluene
µg	micrograms
µg/std m^3	micrograms per standardized cubic meter of air (760 mm Hg, 25°C)
µg/m^3	micrograms per cubic meter
µm	micrometer (micron)
mg/m^3	milligrams per cubic meter
MIBK	Methyl Isobutyl Ketone
mph	miles per hour
MRI	Midwest Research Institute
MST	Mountain Standard Time
NAAQS	National Ambient Air Quality Standards
NAD	North American Datym
NATICH	National Air Toxics Information Clearinghouse
ng/m^3	nanograms per cubic meter
NH_3	Ammonia
NIOSH	National Institute of Occupational Safety and Health
NIST	Nation Institute of Standards and Technology
NMOC	Non Methane Organic Compound
NNDMEA	N-Nitrosodimethylamine
NO	Nitric Oxide
NO_2	Nitrogen Dioxide
NO_x	Nitrogen Oxides

LIST OF ACRONYMS AND ABBREVIATIONS (Cont.)

O_3	Ozone
OCP	Organochlorine Pesticides
OVA	Organic Vapor Analyzer
OVM	Organic Vapor Meter
Parathion	0,0-Diethyl-0(p-nitrophenyl)phosphorothioate
PID	Photoionization Detector
PM-10	Particulates less than 10 micrometers
PMRMA	Program Manager Rocky Mountain Arsenal
ppb	parts per billion
ppbr	parts per billion volume
PPDDE	2,2-Bis(4-chlorophenyl)-1,1-dichloroethylene
PPDDT	1,1-Bis(4-chlorophenyl)-2,2,2-trichloroethane
ppm	parts per million
PSD	Prevention of Significant Deterioration
PUF	Polyurethane Foam
QA	Quality Assurance
QC	Quality Control
RAP	Remedial Action Program
RBACs	Risk-Based Air Concentrations
RfCs	Reference Concentrations
RI	Remedial Investigation
RI/FS	Remedial Investigation/Feasibility Study
RMA	Rocky Mountain Arsenal
SARA	Superfund Amendments and Reauthorization Act
sccm	standard cubic centimeters per minute (760 mm Hg, 25°C)
scfm	standard cubic feet per minute (760 mm Hg, 25°C)
SO_2	Sulfur Dioxide
SOP	Standard Operating Procedures
SQI	Submerged Quench Incinerator
Supona	2-chloro-1-(2,4-dichlorophenyl)vinyl diethyl phosphate
SVE	Soil Vapor Extraction
SVOC	Semivolatile Organic Compounds
111TCE	1,1,1-Trichloroethane
112TCE	1,1,2-Trichloroethane
TCLEE	Tetrachloroethene
TIC	Tentatively Identified Compound
TLV	Threshold Limit Value
tpy	tons per year
TRCLE	Trichloroethene
TSP	Total Suspended Particulates
UATMP	Urban Air Toxic Monitoring Program
UNK	Unknown Number

LIST OF ACRONYMS AND ABBREVIATIONS (Cont.)

USAEHA	U.S. Army Environmental Hygiene Agency
USATHAMA	U.S. Army Toxic and Hazardous Materials Agency
UTM	Universal Transverse Mercator
VOC	Volatile Organic Compounds
VOTA	Volatile Organic Toxic Air collection system (Graseby-Andersen, Inc., trade name
XAD	Adsorbent resin for semivolatile compounds (Supelco, Inc., trade name)
XYLENE	Total Xylenes
%	Percent

4.0 RESULTS OF FY93 PROGRAM

4.1 BASIS OF AIR QUALITY DATA EVALUATION

The purpose of the CAQMMP is to maintain a baseline database to verify ambient air quality at RMA and to evaluate progress made in current and future remedial actions. The program has several related key objectives:

- Evaluate potential air quality health hazards that may exist within the RMA boundaries
- Confirm progress made to date in removing potential air contaminants resulting from previous activities
- Provide standardized procedures of data collection to measure impacts of ongoing remedial activities
- Describe potential impacts of other sources of air pollutants

The data monitoring, verification, and evaluation programs have been designed to achieve these objectives. Additionally, the data analyses have been related to the source of contaminants detected. Source attribution requires consideration of a number of variables unique to air quality assessment:

- Source- and receptor-specific meteorological conditions including wind direction, wind speed, atmospheric stability, mixing height, temperature, and precipitation
- RMA land disturbances, in particular, remedial construction and excavation activities
- Source environment, including topography, soil types, and vegetation
- Ambient air quality concentration levels directly upwind from the RMA area, including metropolitan Denver

In summary, measured background levels of TSP, PM-10, VOCs, SVOCs, OCPs, metals, arsenic, mercury, and asbestos within RMA cannot be evaluated in terms of the stated objectives without identifying causative and contributing factors including off-post sources. Thus, a computer database of ambient air quality concentrations, meteorological data, and significant influencing parameters (e.g., local air contaminant sources) has been established and maintained during the CAQMMP. As the database continues to expand over several years, the statistical significance and additional applications of the database may increase. For example, the progressive effect of previous remedial activities should indicate decreasing concentration levels in the vicinity of

RMA. If certain contaminant levels are above normal background values, a persistence of a given element and/or an indication of the ineffectiveness of remedial actions would be confirmed. Additional or alternate mitigating actions may be required.

During FY93, a full year of data were collected in the vicinity of Basin F under the CAQMMP. In this report, these data are compared with data collected at identical monitoring sites under similar meteorological and climatological conditions during the Basin F remediation period and subsequent post-remedial periods. The basis of this evaluation is discussed further in Section 4.1.2.

4.1.1 Computerized Documentation

Computerized documentation and analysis have provided the following information for this Air Quality Data Assessment Report:

- For each sampling station, a list is provided that includes the compounds detected at that station, the range of concentrations reported, the maximum concentration, pertinent weather conditions, and other factors such as mitigation through remedial activity. High-event monitoring activity was similarly documented and reported.
- Comparison of measured TSP, PM-10, VOCs, SVOCs, OCPs, metals, arsenic, mercury, and asbestos is provided with available regional data, regulatory guidelines, and other toxic guidelines as appropriate. Comparisons with standards and guidelines are discussed further in this report for each specific group of analytes.
- Comparison is provided of significant (high or low) contaminant levels under similar conditions to indicate remedial progress. For example, VOC, SVOC, and OCP values at an RMA site over a particular season could result from remedial activity, transport from off post or specific meteorological conditions. Similarly, high metals levels could result from strong wind speeds from a persistent direction, transport from the metropolitan area, significant RMA excavation activities, or all of the above concurrently. The database

compiled over the life of the CAQMMP describes these relationships for this and future reports.

- Identification is provided of meteorological conditions, excavation activities, or discrete sources and influences that may trigger high levels of contaminant activity and require special precautions and mitigating actions.

In addition, this CAQMMP Air Quality Data Assessment Report provides, for the purpose of remediation assessment, the results of the Interim Action Basin F Cleanup Program from the initiation of remedial activities at Basin F in 1988 through September 30, 1993. Evaluation of RMA data includes the use of the following strategies:

- Incorporate all remedial activity monitoring data into the CAQMMP and assess these data as a subset of the overall database
- Use specific standardized guidelines and criteria for air monitoring support of excavation and remedial activities at RMA. Criteria have been based on available literature, existing state-of-the-art techniques, and direct FY88, FY89, FY90, FY91, FY92 and FY93 experience with air quality monitoring and contaminants of concern at RMA. Guidelines include specific instrumentation, monitoring procedures and techniques, real-time prediction and alert procedures, and models relating to Health and Safety. For example, during FY93 the CAQMMP staff and PMRMA drew upon this experience for planning an air quality program in support of the forthcoming South Plants Pilot Demolition Program.

4.1.2 Basin F Remediation Evaluation

During the CMP FY88 and FY89 periods, Basin F remediation proceeded from March 22, 1988 to May 4, 1989. The post-remediation period, starting May 5, 1989, has continued through the conclusion of CAQMMP FY93. The Basin F Remediation Monitoring Program, the follow-on IRA-F data, and the CMP/CAQMMP programs have provided results of potential air contaminant levels prior to, during, and subsequent to the remediation program. These data reflect

remediation progress. The results of this assessment are provided in this report under the phases and stages shown in Table 4.1-1. All data shown in tables and figures for FY93 cover the period from October 1, 1992, through September 30, 1993, and have been designated Phase 7.

4.1.3 Dispersion Model Application

The CMP/Basin F Air Quality Modeling Programs included the development and/or application of several standard and special purpose models for assessing potential contaminant impacts, including the Industrial Source Complex (ISC) Model and a PUFF advection model (USEPA 1986b). Dispersion modeling assisted appreciably in addressing impacts from potential emission sources, both on and off post. During FY93, dispersion modeling was used to evaluate CAQMMP-monitored data at Basin F, the South Plants, Basin A, the SQI, and other special contingency monitoring events. Both the ISC and PUFF Model were also used effectively in the Basin F cleanup program to assess real-time contamination levels during remedial activities and to provide a forewarning of potential hazardous conditions.

The FY93 Report provides a joint analysis of CAQMMP and Basin F data over a 67-month period to evaluate remedial impacts and post-remedial progress. Dispersion models were used to identify potential source impacts and overriding meteorological influences. One objective was to confirm that concentrations measured under the remedial and post-remedial phase periods occurred during typical meteorological conditions. Figures 4.1-1 and 4.1-2 show mean dispersion patterns for the Phase 1 remediation period and the most recent Phase 7 (FY93) post-remediation period for an area source centered at Basin F. These patterns are closely similar and suggest that anomalous meteorological conditions did not influence results. Similar annual dispersion comparisons have been made in previous post-remedial annual assessments (WCC 1993).

The dispersion patterns are depicted by relating ambient concentration (X) to source strength (Q), incorporating site-specific meteorological factors without source measurements. The X/Q contours were obtained from the EPA ISC Model (using Basin F or other potential emissions sources as a hypothetical area source); they reflect the influences of wind speed, wind direction,

Table 4.1-1 Basin F Remediation Phases

Phase	Dates	Activity	Monitoring Data Available
1	3/22/88 - 12/12/88	Basin F clean-up. Stockpiling of clay for future capping of basin.	CMP FY88, CMP FY89, Basin F Remediation Monitoring Program, RIFS Odor Program
2	12/13/88 - 2/15/89 (Stage 1)	Capping of basin with clay.	CMP FY89, Basin F Remediation Monitoring Program, RIFS Odor Program
	2/16/89 - 6/6/89 (Stage 2)	Capping of basin with topsoil. Grading and reseeding of basin and surrounding area. Liner installed over holding pond.	
3	5/6/89 - 9/30/89	Post-remedial period: Pumping of accumulated waste pile liquids to holding pond.	CMP FY89, IRA-F FY89
4	10/1/89 - 9/30/90	Post-remedial period	CMP FY90, IRA-F FY90
5	10/1/90 - 9/30/91	Post-remedial period	CMP* FY91
6	10/1/91 - 9/30/92	Post-remedial period	CMP* FY92
7	10/1/92 - 9/30/93	Post-remedial period	CAQMMP* FY93

* CMP and CAQMMP are integrations of the CMP and IRA-F monitoring programs designated during the previous monitoring fiscal years.

CMP	-	Comprehensive Monitoring Program
CAQMMP	-	Comprehensive Air Quality and Meteorological Monitoring Program
IRA-F	-	Interim Response Action at Basin F
RIFS	-	Remedial Investigative/Feasibility Study

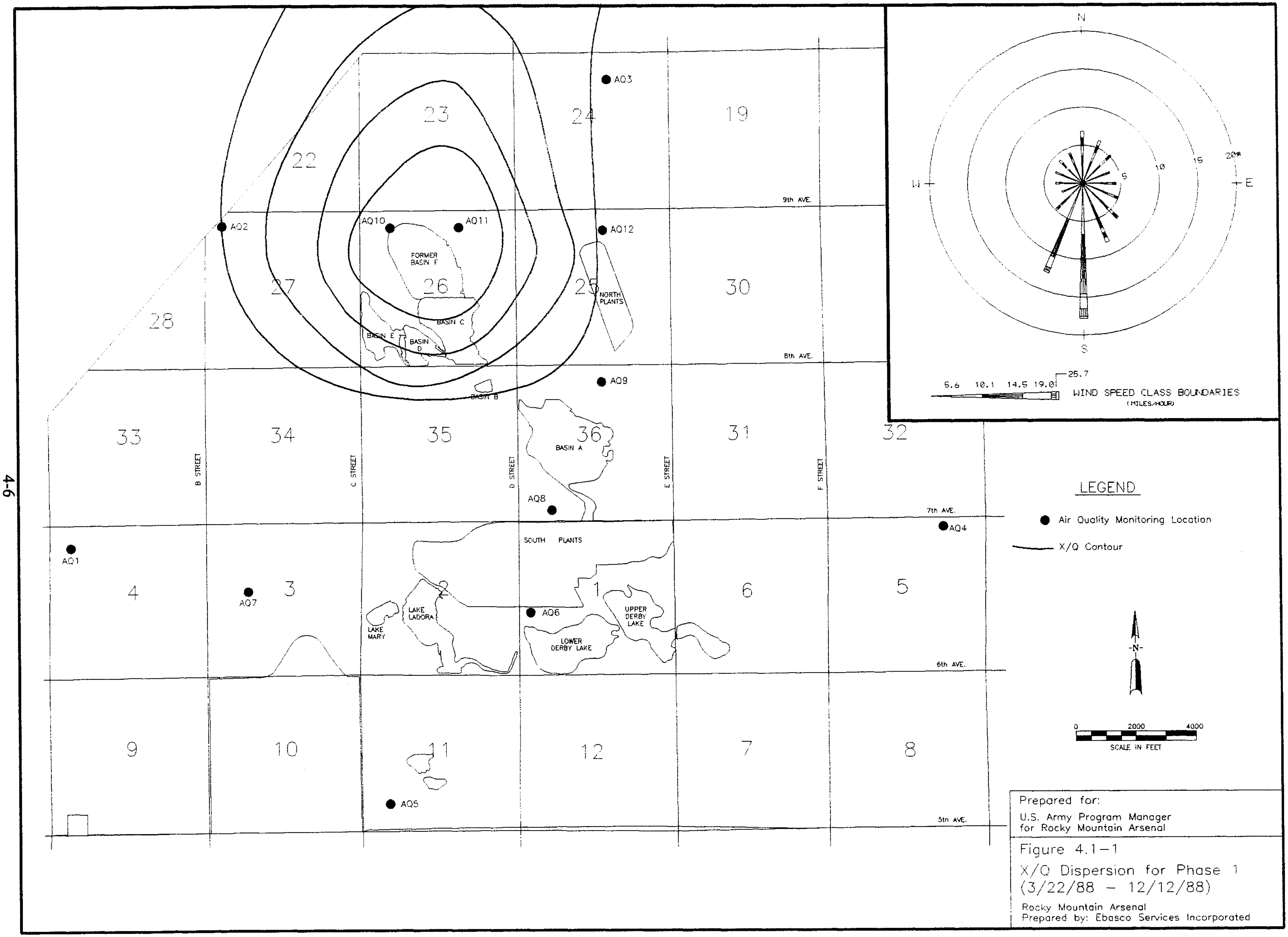

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Figure 4.1-1
X/Q Dispersion for Phase 1
(3/22/88 - 12/12/88)

Rocky Mountain Arsenal
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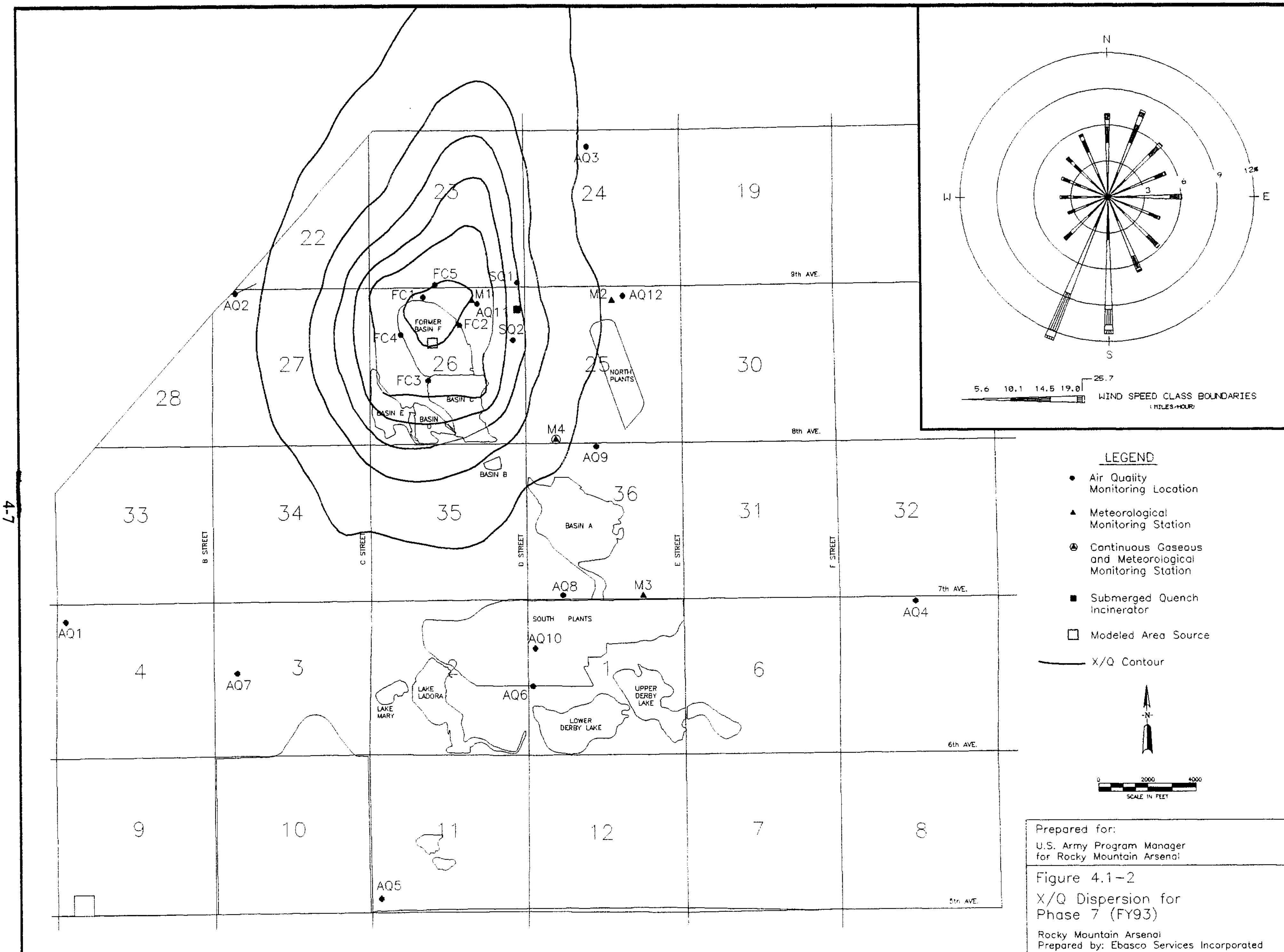

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Figure 4.1-2
X/Q Dispersion for Phase 7 (FY93)

Rocky Mountain Arsenal
Prepared by: Ebasco Services Incorporated

atmospheric stability, and inversion conditions on the spread of pollutants for the monitoring period. The X/Q values do not indicate actual ambient concentration, but indicate relative strength, or potential for concentration levels, based on meteorological conditions and a unitized (1 gram per second) source strength (see Section 6.5 for a further description of CAQMMP–employed dispersion models). During remediation, higher measured ambient concentration levels corresponding to high X/Q values were found close to the Basin F source and directly downwind from prevailing winds. The dispersion patterns were also skewed to the north of Basin F, reflecting the prevailing air flow during the monitoring periods, as shown in the wind rose insert in Figures 4.1-1 and 4.1-2. Thus, higher ambient concentrations as a result of potential Basin F source contaminants during remediation activities were confirmed by modeling and suggested the model's further application for prediction and extrapolation.

As stated, the dispersion patterns were closely similar for each phase of the remediation and post-remediation periods. The implication, therefore, is that the dispersion characteristics defined by the measured meteorology were similar during the 7 phases. Therefore, any significant variations in measuring air quality data are a function of source emissions. For example, high pesticide levels were noted during the Phase 1 period. During Phase 2, Phase 3, Phase 4, Phase 5, Phase 6 and Phase 7, these contaminant levels decreased significantly (under similar dispersion conditions), implying that the potential Basin F emissions sources for these compounds were effectively contained at the conclusion of the Phase 1 period.

The X/Q approach, which has been effective in evaluating Basin F remediation progress, will be employed for the assessment of other potential RMA sources such as the South Plants, Basin A, and the SQI facility.

4.1.4 Source Emission Factors

One objective of the air quality assessment is to identify emission sources that contribute to ambient air levels measured by the RMA monitoring program. The CMP demonstrated that Basin F was a potential source of several VOCs, SVOCs, and metals compounds associated with

the remedial programs during FY88. High TSP levels were also evident at Basin F as a result of intense remedial construction activity. Significant decreases in ambient levels for most of these compounds occurred during Phases 3, 4, 5, 6 and 7 post-remediation periods, reflecting decreased emissions from Basin F and the associated remedial program.

As Basin F emissions decrease, other RMA sources could come into focus, such as Basin A, the South Plants, the SQI facility, and localized construction activities. These sources, as of the FY93 data collection period, appear to be at lower levels of intensity than metropolitan Denver, and in most cases their impacts are comparable to or less than VOC, OCP, and metals levels measured there.

It is important to note that CAQMMP monitoring results are difficult to evaluate for most pollutants measured during FY93 without examining the potential emission sources across the Denver urban area. A number of mobile and stationary sources in metropolitan Denver may impact CAQMMP air quality monitoring sites, depending upon wind direction, inversion conditions, temperature, and other meteorological factors influencing the Denver area. This report further identifies these external conditions and sources. Table 4.1-2 and Figure 4.1-3 show selected criteria pollutant sources in metropolitan Denver that may influence RMA air quality under certain meteorological conditions. TSP point sources are further identified in Table 4.2-8 and Figure 4.2-4; VOC point sources are further identified in Tables 4.6-8, and 4.6-9 and Figure 4.6-13 in Section 4.6.6 of this report.

4.2 TOTAL SUSPENDED PARTICULATES

4.2.1 CAQMMP FY93 TSP Results

As discussed in Section 2.1.1.1, TSP regulatory standards are in the process of review and revision by CDH. Nevertheless, TSP data collected at RMA over the past 6 years have been a strong indicator of remedial activity and progress; as such, TSP data continue to be a significant tool for evaluating important assessment criteria pertaining to air quality. A summary of data sampling frequency and recovery for the FY93 monitoring program for TSP at each of the

Table 4.1-2 Emission Inventory Summary for Regulated Pollutants (tons per year)

Facility	Map #	Total Emissions				
		VOC[1]	TSP[2]	SO_2[3]	NO_2[4]	CO[5]
Chemical Systems Technology, Inc	1	6655				
Colorado Refining Co. / Total Petroleum	2	989	174	632	288	141[6]
Conoco Inc. - Denver Refinery	3	740	465	2336	626	272[6]
Denver Industrial Sales & Service	4	257				
WYCO Pipe Line Co. DuPont Terminal	5	236				
Pillow Kingdom MFG	6	213				
Swedish Medical Center	7	155				2
Union Chemicals Division	8	143				
Chase Terminal Co.	9	121				
Mastercraft	10	120				
Kiewit Western	11		1830	16		
Denver Metals	12		336			
Public Service Co. - Cherokee	13	72	254	13362	14295	550[6]
Public Service Co. - Arapahoe	14	17	94	4567	5143	160[6]
Waste Management of CO - Arapahoe	15		72			
Cooley Gravel Co. 88th & Riverdale	16		70			
Purina Mills Inc. - Henderson Mill	17		66			
Centennial Materials - Thornburg	18		65			
Cooley Gravel	19		64			
BFI - Tower Landfill	20		58	1		3
Metro Wastewater Reclamation	21	25		134		84
Buckley Air National Guard Base	22	17	27	37	263	56
Owens Corning Fiberglass - Trumbull	23		27	29		42
General Chemical Corporation	24			28		
Gates Rubber Company	25	118		28	245	
Bar S Foods Company	26			25		
Fast Construction Company	27		32	25		
Amoco Production Co. - Wattenberg	28	116		24		
Asarco Inc. - Globe Plant	29			18		
Brannan S & G	30	17	29	16		

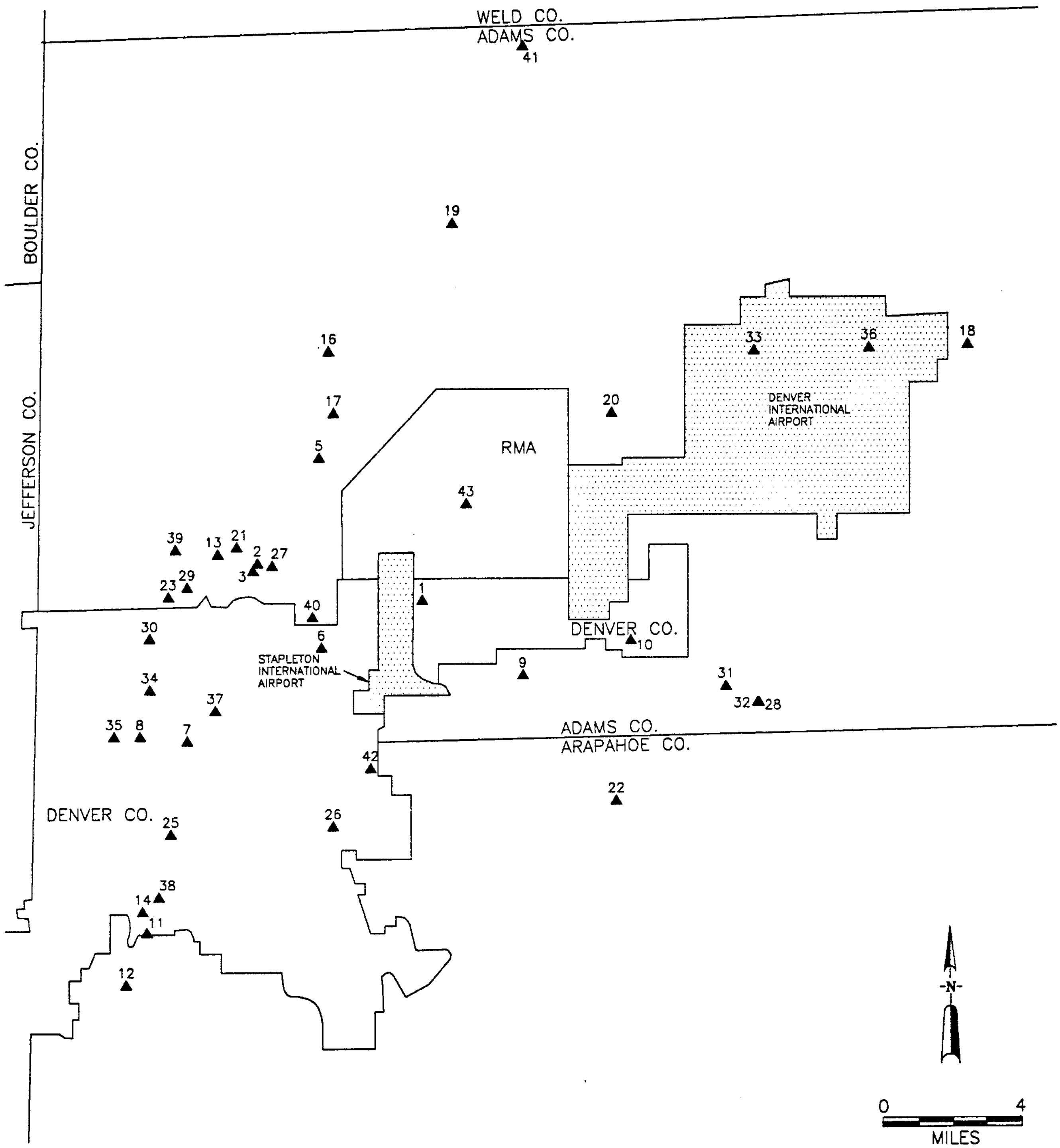
Table 4.1-2 Emission Inventory Summary for Regulated Pollutants (tons per year)

Facility	Map #	Total Emissions VOC[1]	TSP[2]	SO_2[3]	NO_2[4]	CO[5]
Colo Interstate Gas Co. - Watkins	31	55			866	335
Amoco Production - Wattenberg	32	116		24	549	
Koch Hydrocarbon Co. - Third Creek	33	18			504	
Public Service Co. - Delganey	34				313	23
Koch Hydrocarbon Co. - Mitchell					176	22
Koch Hydrocarbon Co. - Radar Plant					153	19
Koch Hydrocarbon Co. - Dragoon					146	19
Public Service Co. - Zuni	35			2	146	11
Colo. Interstate Gas Co. - Latigo					126	16
Koch Hydrocarbon Co. - Boxelder	36				115	15
Explosive Fabrics						17
Presbyterian/St. Lukes Healthcare	37					74
Littleton/Englewood WWTP	38					11
Koch Hydrocarbon Co. - Rattlesnake						10
ITT Continental Baking Co.	39					9
Schafer Commercial Seating Inc.	40					9
Panhandle Easter Pipeline Co.	41					9
Lowry Air Force Base	42	45				9
Koch Hydrocarbon Co. - Antelope						9
Irondale Gas Processing Co.						8
Rocky Mountain Arsenal	42	1.1	1.1	6	32.6	7

Source: Colorado Department of Health EISPS Inventory, 1993.

1 Blank entry indicates total annual VOC emissions of less than 15 tons per year or did not report VOC emissions.
2 Blank entry indicates total annual TSP emissions of less than 25 tons per year or did not report TSP emissions.
3 Blank entry indicates total annual SO_2 emissions of less than 1 ton per year or did not report SO_2 emissions.
4 Blank entry indicates total annual NO_2 emissions of less than 5 tons per year or did not report NO_2 emissions.
5 Blank entry indicates total annual CO emissions of less than 1 ton per year or did not report CO emissions.
6 CO emissions based on FY92 data report.

VOC - Volatile Organic Compounds
TSP - Total Suspended Particulates
SO_2 - Sulfur Dioxide
NO_2 - Nitrogen Dioxide
CO - Carbon Monoxide



▲ - Facility Map Number; See Table 4.1-2

Prepared for:
U.S. Army Program Manager for Rocky Mountain Arsenal

Figure 4.1-3

Emission Inventory Summary for Regulated Pollutants

Rocky Mountain Arsenal
Prepared by: Ebasco Services Incorporated

monitoring locations is presented in Table 4.2-1. Recoveries are based on the total number of scheduled days during the monitoring year. Samples were considered not valid if there were equipment malfunctions or the sample filter was damaged. According to PSD guidelines, a minimum of 23 hours of sampling was required for a valid sample.

At the beginning of the FY93 CAQMMP, problems not previously experienced were observed with the TSP gravimetric analyses including filter blanks showing negative weights or significant high values, PM-10 values greater than TSP values at the same sampling location, and duplicate (collocated) samples showing significant variations. These difficulties were principally attributed to excessive and uncontrolled static electricity on the filters, so more stringent controls and quality assurance procedures were implemented, including use of a controlled weighing environment, use of anti-static devices, and increased replication of pre- and post-sampling filters. Significant improvement was achieved after January 31, 1993. Consequently, only the TSP and PM-10 results subsequent to this date are included in the summary analyses. All TSP sample analysis results obtained in FY93 (October 1992 to September 30, 1993) are provided in Appendix A. Much of the data prior to February 1, 1993 may be reliable and can be considered qualitatively on a case-by-case basis; however, because of the general concerns discussed above they are excluded from the fiscal year summaries. The last column in Table 4.2-1 reflects the percentage of FY93 TSP data considered in the TSP summary analyses.

TSP data are often reported by using the annual geometric mean values. This approach is based on early EPA guidance and is applied because the TSP monitoring data can be expected to fit a log-normal distribution. Under a log-normal distribution, there are a relatively large number of low concentrations and a small number of high concentrations. An arithmetic mean value would be greatly affected by the few very large values, while a geometric mean is much less affected by these extremes.

An arithmetic mean can be characterized as follows:

Table 4.2-1 Summary of Total Suspended Particulate Monitoring for FY93 Page 1 of 1

Station	Samples Scheduled	Samples Collected	Valid Samples	Field % Recovery	Overall % Recovery
AQ1	61	59	37	97	61
AQ2	61	58	35	95	57
AQ3	61	59	37	97	61
AQ4	61	52	32	85	52
AQ5	61	60	35	98	57
AQ6	61	60	34	98	56
AQ7	61	60	39	98	64
AQ8	61	59	38	97	62
AQ9	61	59	35	97	57
AQ10	61	60	40	98	66
AQ11	61	60	39	98	64
AQ12	61	60	40	98	66
FC1	31	31	22	100	71
FC2	31	30	21	97	68
FC3	12	13	9	108	75
FC4	12	13	9	108	75
FC5	31	30	21	97	68
SQ1	61	60	36	98	59
SQ2	61	59	38	97	62
Duplicate	61	59	35	97	57
Overall	1,032	1,001	632	97	61

% Percent

$$A = \frac{(a_1 + a_2 + a_3 + \ \dots \ + a_n)}{n}$$

While a geometric mean is the nth root of the product of the n observations:

$$G = (a_1 * a_2 * a_3 \dots a_n)^{1/n}$$

Where

a_n is the nth observation (of TSP data);

n is the total number of valid observations;

A is the arithmetic mean of the sample; and

G is the geometric mean of the sample.

Monthly and annual TSP results for FY93 for each monitoring station are summarized in Tables 4.2-2, 4.2-3, and 4.2-4. Table 4.2-2 provides the annual geometric mean values; Table 4.2-3 provides the annual arithmetic mean values; and Table 4.2-4 provides 24-hour maximum concentrations. The arithmetic mean is provided for continuity purposes and for comparison with previous historical data. The 24-hour sequential data are also provided in Appendix A. Figures 4.2-1 and 4.2-2 (for Basin F monitoring sites) provide graphical depictions of these data and comparisons with the annual standards.

Annual arithmetic mean values for TSP during FY93 ranged from a high of 56 $\mu g/m^3$ at AQ2 on the northwest perimeter of RMA, to a low of 34 $\mu g/m^3$ at AQ12 just north of the North Plants. The location of the maximum TSP concentration indicated influences from the Denver Metropolitan area. Annual geometric mean values ranged from a high of 51 $\mu g/m^3$ at perimeter site AQ2 to a low of 28 $\mu g/m^3$ at interior site AQ12. Table 2.1-1 shows all ambient air quality standards.

Table 4.2-2 Total Suspended Particulate (TSP) Sampling Results For FY93, Geometric Mean Concentrations ($\mu g/m^3$)

	AQ1	AQ2	AQ3	AQ4	AQ5	AQ6	AQ7	AQ8	AQ9	AQ10	AQ11	AQ12	SQ1	SQ2	FC1	FC2	FC3	FC4	FC5
October*																			
November*																			
December*																			
January*																			
February	78	78	45	40	71	47	56	45	46	46	46	35	45	45	45	47	58	59	53
March	58	48	28	36	36	30	37	42	30	33	31	24	34	28	36	24	31	30	27
April	16	29	20	12	13	19	14	25	12	24	9	9	19	17	12	15	9	7	19
May	37	43	29	37	30	30	31	27	27	29	31	30	31	32	27	26	20	14	29
June	41	43	38	38	35	31	35	30	32	31	35	32	41	34	30	30	23	7	39
July	42	68	44	50	41	36	24	38	40	37	36	36	41	42	33	34	28	32	38
August	45	63	38	57	41	35	40	37	39	40	40	44	43	42	49	37	47	43	39
September	47	62	48	52	38	40	41	41	40	39	39	39	47	42	45	38	36	32	47
Annual	41	51	34	42	36	31	32	34	31	34	31	28	36	32	33	30	29	24	36

* - As noted in text, data for these months were not considered sufficiently reliable to include in the summaries.

$\mu g/m^3$ - Micrograms per cubic meter

RMA/0880 10/05/94 4:13 pm bpw

Table 4.2-3 Total Suspended Particulate (TSP) Sampling Results For FY93, Arithmetic Mean Concentrations ($\mu g/m^3$)

	AQ1	AQ2	AQ3	AQ4	AQ5	AQ6	AQ7	AQ8	AQ9	AQ10	AQ11	AQ12	SQ1	SQ2	FC1	FC2	FC3	FC4	FC5
October*																			
November*																			
December*																			
January*																			
February	82	81	47	41	80	48	60	46	47	47	48	37	48	47	47	48	58	59	54
March	66	51	33	38	44	33	46	50	34	39	41	32	43	33	42	30	31	30	28
April	18	34	23	12	14	22	15	45	14	33	13	12	22	20	14	17	9	7	26
May	38	44	30	39	31	31	32	28	28	30	32	31	33	33	27	26	20	14	29
June	47	48	42	47	42	38	43	38	39	41	44	40	49	41	45	39	40	7	58
July	44	70	45	56	43	37	30	40	42	39	37	38	43	42	34	35	28	32	39
August	46	64	41	60	42	37	41	38	39	40	41	45	45	43	49	37	47	43	50
September	49	64	50	54	39	41	43	42	41	40	40	40	48	43	46	39	37	32	48
Annual	47	56	38	47	42	35	38	40	35	38	37	34	41	37	38	34	35	29	42

* - As noted in the text, data for these months were not considered sufficiently reliable to include in the summaries.
$\mu g/m^3$ - Micrograms per cubic meter

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Table 4.2-4 Total Suspended Particulate (TSP) Sampling Results For FY93, 24-Hour Maximum Concentration ($\mu g/m^3$) Page 1 of 1

	AQ1	AQ2	AQ3	AQ4	AQ5	AQ6	AQ7	AQ8	AQ9	AQ10	AQ11	AQ12	SQ1	SQ2	FC1	FC2	FC3	FC4	FC5
October*																			
November*																			
December*																			
January*																			
February	105	109	63	46	126	57	91	61	58	62	63	50	65	60	60	58	58	59	61
March	128	90	68	69	121	65	103	87	71	73	110	80	97	80	69	64	31	30	34
April	26	66	48	12	21	42	25	149	19	67	23	23	42	42	19	25	9	7	42
May	58	61	51	58	46	52	44	45	39	47	53	41	59	48	34	28	20	14	35
June	72	63	71	90	73	82	76	70	73	83	77	70	92	79	78	67	73	7	94
July	59	88	67	91	55	50	51	50	57	53	48	50	59	56	40	43	28	32	47
August	56	78	56	86	58	50	46	49	48	53	50	59	60	54	55	47	47	43	59
September	74	85	67	71	51	58	66	62	54	55	56	54	67	59	58	54	46	37	58
Annual	128	109	71	91	126	82	103	149	73	83	110	80	97	80	78	67	73	59	94

* - As noted in the text, data for these months were not considered sufficiently reliable to include in the summaries.
$\mu g/m^3$ - Micrograms per cubic meter

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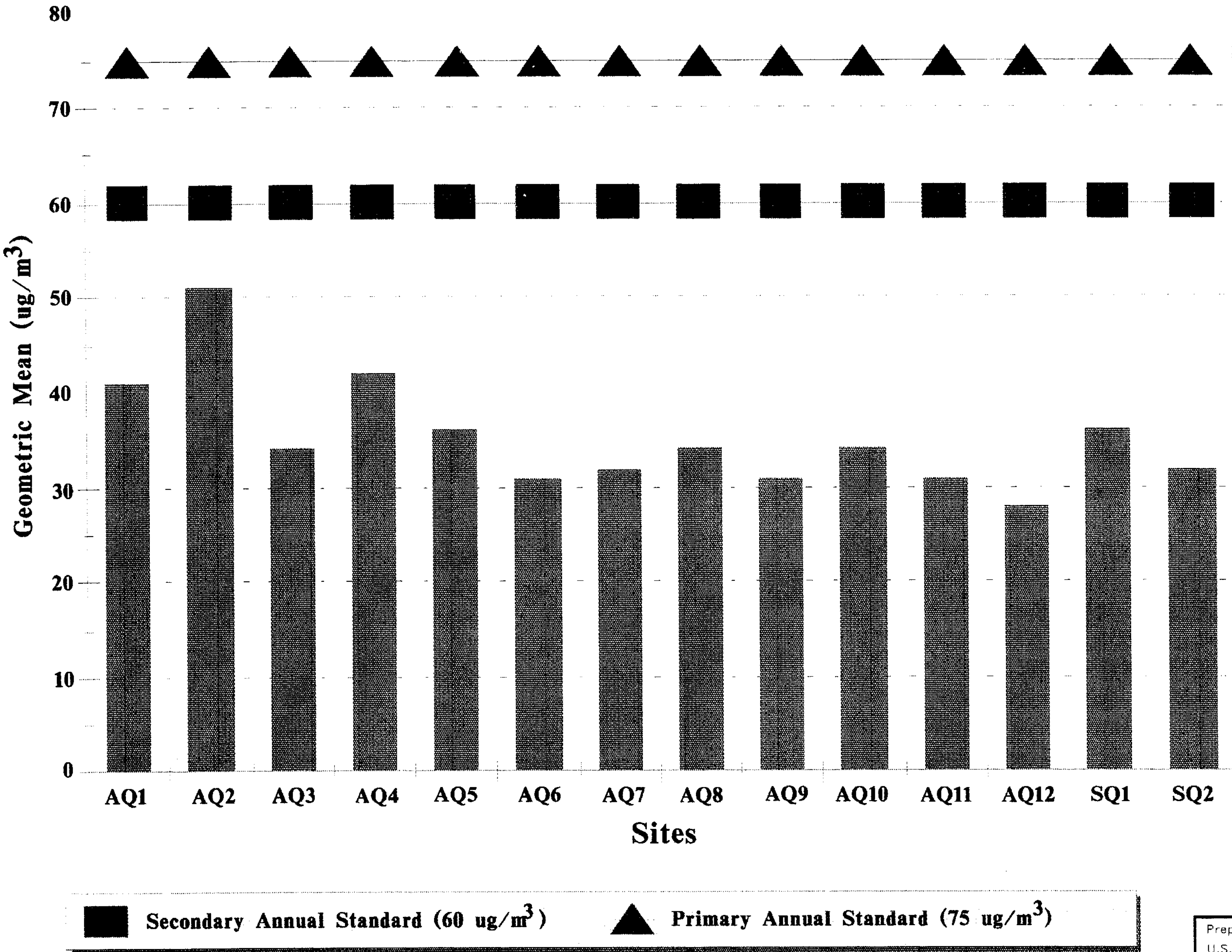
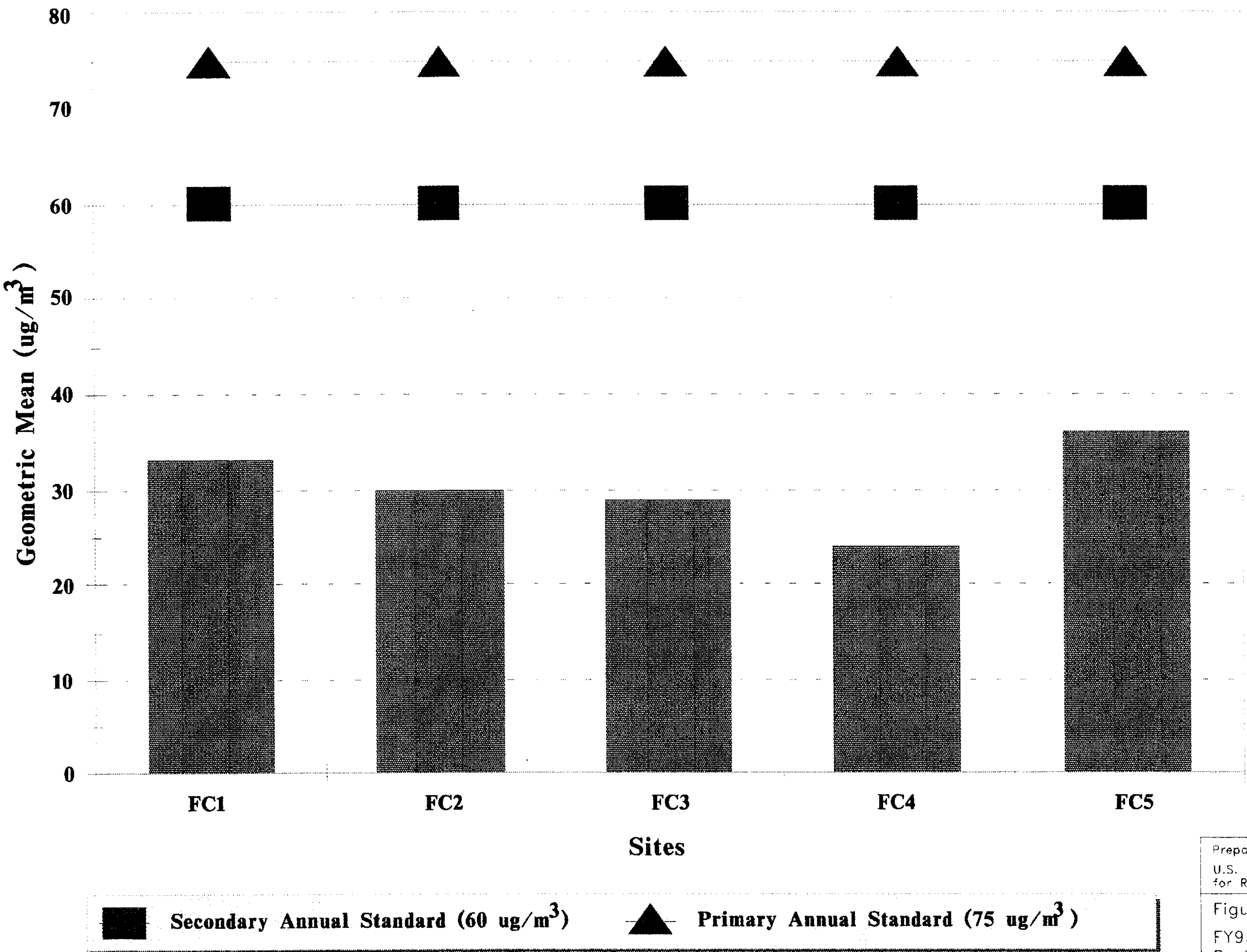


Prepared for:
U.S. Army Program Manager
for Rocky Mountain Arsenal

Figure 4.2-1

CMP FY93 Total Suspended Particulate Results

Rocky Mountain Arsenal
Prepared by: Ebasco Services Incorporated



Prepared for:
U.S. Army Program Manager for Rocky Mountain Arsenal

Figure 4.2-2

FY93 FC Total Suspended Particulate Results

Rocky Mountain Arsenal
Prepared by: Ebasco Services Incorporated

There were no exceedances of the 24-hour primary ambient air quality standard of 260 μg/m^3 for TSP and one exceedance of the secondary 24-hour average ambient air quality standard of 150 μg/m^3 during FY93. By contrast, there were 27 exceedances of the 24-hour TSP secondary standard during FY89; all of these exceedances occurred during the Basin F remediation period and almost all were at sites close to Basin F cleanup activities.

The maximum validated 24-hour concentration during FY93 was 154 μg/m^3 at AQ6. In addition, on December 8, 1993, a day when the downtown Denver CAMP Station measured 610 μg/m^3 and all other Denver TSP stations recorded maximum values, 16 of the 18 RMA stations measured TSP values in excess of 100 μg/m^3 with a maximum 24-hour value of 179 μg/m^3 measured at AQ1 at the Arsenal western boundary. As this occurred during the period when static electricity on the filters resulted in unreliable data (the blank filter on this date measured 53 μg), these results have been excluded from the summary tables. Nevertheless, these data are consistent with metropolitan Denver data and appear qualitatively useful. The December 8th sampling results including the RMA and TSP data for this date are reviewed further in Section 4.2.4.

4.2.2 Assessment of Basin F TSP Post-Remedial Impacts

One of the principal tasks of the CAQMMP has been the assessment of Basin F post-remedial impacts and progress. Since source impacts from Basin F have varied during the remedial and post-remedial monitoring periods, results and comparisons with all monitored data were considered with respect to the different phases and stages of the cleanup operations. Tables 4.2-5 and 4.2-6 (for Basin F sites) provide listings of annual geometric mean, arithmetic average and 24-hour maximum TSP monitoring results at air monitoring sites from the start of FY89 to the conclusion of FY93. Phase 1 shows results of FY88 and FY89 data, which were concurrent with remediation activity; Phase 2 (Stage 1) shows results of the FY89 program after the initial cap was placed on Basin F and extensive earth moving activities were in progress; and Phase 2 (Stage 2) shows results during the final Basin F remedial and landscaping activity. Phases 3 through 7 provide post-remedial TSP monitoring data during the CAQMMP periods of subsequent monitoring through FY93.

Table 4.2-5 Total Suspended Particulate (TSP) Sampling Results for CMP Phases 1 through 7 ($\mu g/m^3$)

Phase	AQ1	AQ2	AQ3	AQ4	AQ5	AQ6	AQ7	AQ8	AQ9	AQ10	AQ11	AQ12	SQ1	SQ2
Summary of Geometric Mean Concentrations														
Phase 1	50	68	40	40	39	35	40	40	38	81	74	55		
Phase 2-1	58	76	37	40	48	33	38	39	31	68	145	49		
Phase 2-2	44	58	26	27	37	29	30	29	28	44	72	41		
Phase 3	42	52	37	37	36	36	38	38	32	41	37	36		
Phase 4	40	52	32	27	33	36	32	31	28	30	30	28		
Phase 5	40	52	35	33	39	34	34	34	30	34	41	47	40	40
Phase 6	48	54	37	39	39	36	39	42	37	34	42	37	46	44
Phase 7	41	51	34	42	36	31	32	34	31	34	31	28	36	32
Summary of Arithmetic Mean Concentrations														
Pre-Rem	55	52	35	42	42	38	39	38	36	44	38	35		
Phase 1	56	77	47	47	43	39	45	44	43	99	103	79		
Phase 2-1	73	88	44	37	62	45	50	47	41	84	214	81		
Phase 2-2	49	64	30	31	42	32	34	34	31	51	96	77		
Phase 3	46	61	41	42	40	40	42	43	36	46	41	40		
Phase 4	47	63	39	33	40	55	38	37	34	35	37	34		
Phase 5	46	61	41	39	46	39	40	41	34	40	55	42	47	48
Phase 6	51	59	40	44	43	39	42	46	39	43	47	41	51	48
Phase 7	47	56	38	47	42	35	38	40	35	38	37	34	41	37

Table 4.2-5 Total Suspended Particulate (TSP) Sampling Results for CMP Phases 1 through 7 ($\mu g/m^3$)

Phase	AQ1	AQ2	AQ3	AQ4	AQ5	AQ6	AQ7	AQ8	AQ9	AQ10	AQ11	AQ12	SQ1	SQ2
Summary of 24-hour Maximum Concentrations														
Pre-Rem	143	112	80	47	109	151	101	95	82	71	91	77		
Phase 1	134	196	96	120	87	86	91	87	93	279	542	590		
Phase 2-1	179	198	113	102	183	143	156	130	127	175	738	425		
Phase 2-2	86	115	53	58	75	57	59	78	65	122	294	467		
Phase 3	82	130	82	92	79	76	78	84	76	90	84	86		
Phase 4	184	208	194	171	170	396	180	188	164	100	214	167		
Phase 5	113	202	119	116	100	93	127	103	96	102	286	95	94	116
Phase 6	115	140	83	130	84	83	88	138	90	105	120	117	129	120
Phase 7	128	109	71	91	126	82	103	149	73	83	110	80	97	80

Note: Pre-Rem refers to data collected during the Air Remedial Investigation, June 1986 to June 1987, where only arithmetic mean and maximum data were available

Phase 1 is from March 22 to December 12, 1988.
Phase 2, Stage 1 is from December 13, 1988 to February 15, 1989.
Phase 2, Stage 2 is from February 15 to May 5, 1989.
Phase 3 is from May 6 to September 30, 1989
Phase 4 is from October 1, 1989 to September 30, 1990.
Phase 5 is from October 1, 1990 to September 30, 1991.
Phase 6 is from October 1, 1991 to September 30, 1992.
Phase 7 is from October 1, 1992 to September 30, 1993.

$\mu g/m^3$ - Micrograms per cubic meter

Table 4.2-6 Total Suspended Particulate (TSP) Sampling Results for Basin F/IRAF Phases 1 through 7 ($\mu g/m^3$)

Phase	BF1/FC1	BF2/FC2	BF3/FC3	BF4/FC4	FC5
Summary of Geometric Mean Concentration					
Phase 1	105	122	68	117	
Phase 2-1	78	119	53	72	
Phase 2-2	62	81	55	80	
Phase 3	49	39	44	42	54
Phase 4	39	36	32	35	44
Phase 5-1	44	32	31	36	40
Phase 5-2	32	36	31	33	31
Phase 6	45	38	37	38	48
Phase 7	33	31	27	23	36
Summary of Arithmetic Mean Concentration					
Phase 1	123	173	83	137	
Phase 2-1	96	173	60	79	
Phase 2-2	66	110	60	88	
Phase 3	53	43	47	46	57
Phase 4	49	46	40	43	62
Phase 5-1	91	34	36	43	48
Phase 5-2	37	41	34	35	45
Phase 6	49	44	41	43	54
Phase 7	38	35	34	29	42

Table 4.2-6 Total Suspended Particulate (TSP) Sampling Results for Basin F/IRAF Phases 1 through 7 ($\mu g/m^3$)

Phase	BF1/FC1	BF2/FC2	BF3/FC3	BF4/FC4	FC5
Summary of 24-Hour Maximum Concentration					
Phase 1	399	902	286	324	
Phase 2-1	276	687	143	162	
Phase 2-2	107	514	107	160	
Phase 3	105	89	94	103	87
Phase 4	227	220	173	181	471
Phase 5-1	410	54	67	104	115
Phase 5-2	87	98	60	51	87
Phase 6	82	78	73	71	96
Phase 7	78	67	73	59	94

Note: Phase 1 is from March 22 to December 12, 1988.
Phase 2, Stage 1 is from December 13, 1988 to February 15, 1989.
Phase 2, Stage 2 is from February 16, 1989 to May 5, 1989.
Phase 3 is from May 5 to September 30, 1989.
Phase 4 is from October 1, 1989 to September 30, 1990.
Phase 5, Stage 1 is from October 1, 1990 to January 22, 1991.
Phase 5, Stage 2 is from January 23, 1991 to September 30, 1991.
Phase 6 is from October 1, 1991 to September 30, 1992.
Phase 7 is from October 1, 1992 to September 30, 1993.

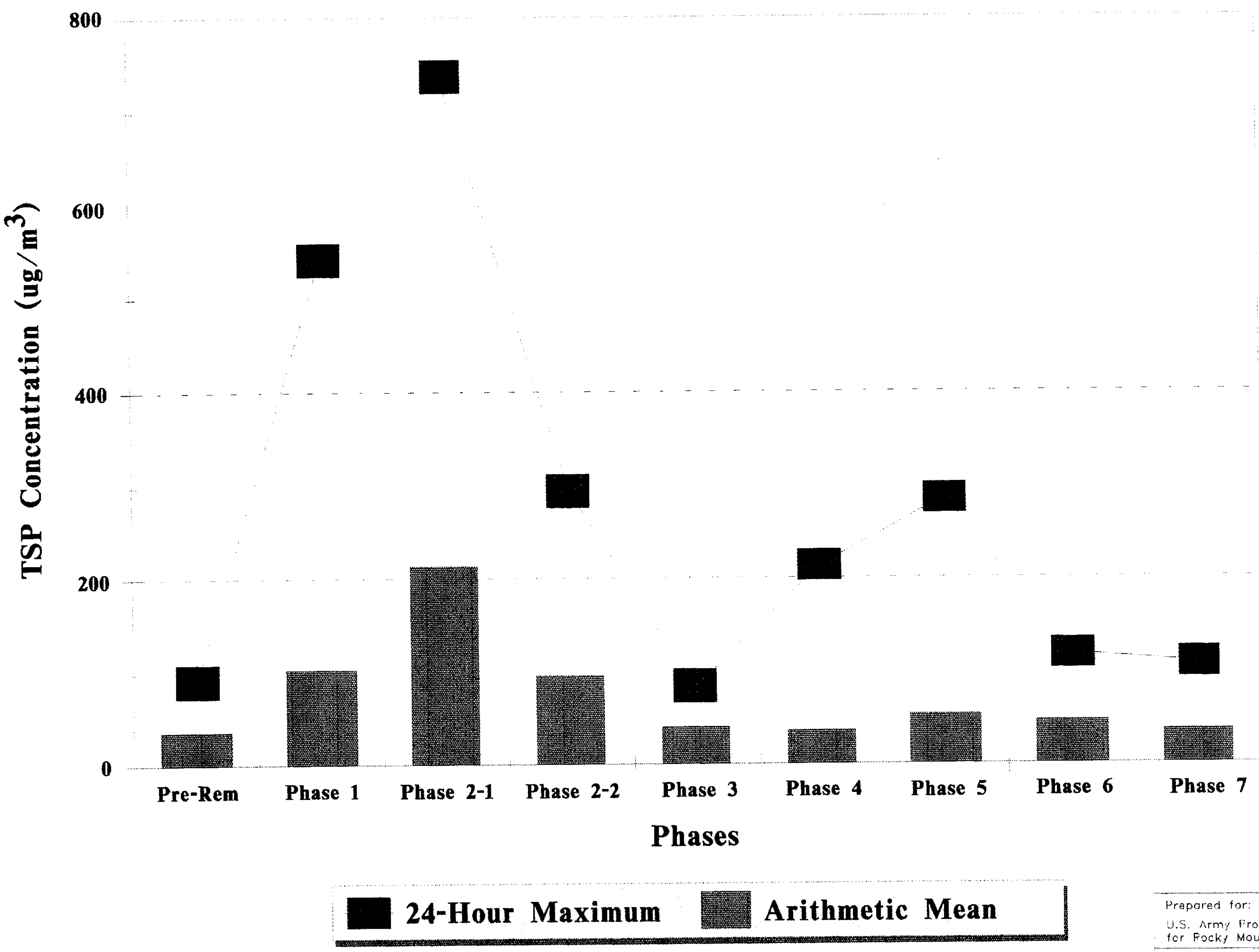
The Basin F sites were designated as "FC" sites upon commencement of the IRA-F program. Sites BF3 and BF4 remained in operation until June 1989, when they were moved slightly within the same area designated as "FC" sites under the IRA-F program.

$\mu g/m^3$- Micrograms per cubic meter

Note that the AQ sites (Table 4.2-5) reflect little variation throughout the seven-phase remediation and post-remediation periods, with the exception of AQ10 and AQ11, directly downwind from Basin F during the remediation activities. On the other hand, Basin F remedial activity (as reflected primarily in Table 4.2-6) evidently had an impact on those stations that were located immediately adjacent to Basin F and also downwind from the basin. The highest monthly average and maximum 24-hour concentrations occurred during Phase 1, and in Phase 2 (Stage 1) when earth moving activities were most intense. A maximum 24-hour TSP value of 902 $\mu g/m^3$ was measured at BF2/FC2, and a maximum of 738 $\mu g/m^3$ was measured at AQ11. At all stations, TSP levels decreased to pre-remedial baseline values during the post-remedial periods (Phases 3, 4, 5, 6, and 7). Figure 4.2-3 provides a graphical depiction of the arithmetic means and 24-hour maximum values for each phase for CMP station AQ11 immediately downwind and north of Basin F. The transitory impacts of remediation activity are evident based on the TSP concentration differences between the remedial and post-remedial phases. Mean TSP levels reached their peaks during the intense remediation of Phases 1 and 2, then decreased to pre-remedial levels during the post-remediation periods. While maximum 24-hour values may have varied extensively on a day-to-day basis, with higher 24-hour levels occurring in Phases 4 and 5 due to local construction activities, the same general trend is evident for the average values.

It is noted that at the conclusion of the CAQMMP FY93 period, the Basin F (FC) stations were comparable to or lower than other interior stations. Station FC5 showed slightly higher geometric mean and maximum 24-hour levels than other FC stations; however, this can be accounted for by its close proximity to Ninth Avenue (within RMA), which is a gravel surfaced road, and also to the nearby tank farm which has generated considerable traffic. More detailed discussions of Basin F TSP impacts at individual stations on a monthly and seasonal basis have been provided in previous CMP/CAQMMP annual reports.

Five years of intensive post-remedial monitoring at sampling sites surrounding Basin F have indicated that TSP impacts from the restored basin are minimal and comparable to other Arsenal



Prepared for:
U.S. Army Program Manager
for Rocky Mountain Arsenal

Figure 4.2-3
AQ11TSP Results during all Phases of Basin F Remediation

Rocky Mountain Arsenal
Prepared by: Ebasco Services Incorporated

interior levels. It is anticipated that future TSP monitoring at Basin F will be conducted at one downwind site and one upwind site.

4.2.3 RMA TSP Causal Effects

Several studies were conducted (CMP FY88 and FY89) relating the impacts of wind gusts and source locations to TSP concentrations measured at the various monitoring locations. This section provides a brief summary and update on the status of these investigations. The causal effects of TSP concentrations at RMA monitoring sites are varied and cannot be reduced to two or three sources or unique meteorological events. The impacts of Basin F remediation activity were described in the previous section. The impacts from metropolitan Denver are also significant and will be discussed further in Section 4.2.4. Other factors such as wind speed, wind direction, precipitation, inversion conditions, seasonal and climatological effects, and various construction and remediation activities at RMA all influence the short-term and long-term monitoring results.

In the CMP FY88 Data Assessment Report, a direct correlation was established between 24-hour TSP levels and strong winds blowing downwind from a remediation source. During the FY88 remediation period, AQ11, downwind from Basin F, showed a correlation of 0.4 between TSP levels and winds blowing from the Basin toward the station (±30°). Further downwind at other RMA sites, the relationship was no longer evident, indicating that these effects were not only dependent on wind speed and wind direction, but also on distance. The TSP concentration data suggest that at a distance of 1 mile, remediation impacts became minimal. During FY89 when the Basin F remediation work was completed, the correlation between high TSP levels at AQ11 and winds blowing off Basin F was no longer observed (the correlation was -0.03). The observed data indicated that Basin F was a major TSP source during the remediation activity, but was largely eliminated during the post-remedial period except for minor residual impacts associated with continuing reseeding and construction activities.

A long-term statistical analysis of RMA data indicates other unique remediation and construction activities associated with the data collection period. For example, during FY88 and FY89, the Borrow Pit, which was used as fill dirt for Basin F remediation, contributed significantly to TSP concentrations measured at AQ12 (reaching a peak 24-hour concentration of 590 $\mu g/m^3$); however, these levels decreased in FY90. During FY91, TSP concentrations at AQ11 and AQ12 increased, apparently as a result of regional influences. During FY92, activity from the Lower Derby Lake Spillway area strongly influenced TSP levels as evidenced by higher TSP concentrations measured at AQ6 (maximum 24-hour concentrations, 396 $\mu g/m^3$).

During the past several years, TSP measurements at AQ4, which is located in a rural area at the southeastern boundary of RMA, have shown a slight but steady increase in ambient concentration levels. The annual geometric mean level at this site has increased from 27 $\mu g/m^3$ in 1990, to 33 $\mu g/m^3$ in 1991, to 39 $\mu g/m^3$ in 1992, and to 42 $\mu g/m^3$ in 1993 (excluding winter data in 1993). Although annual meteorological influences may be a partial factor, it would also appear that increased traffic on the eastern perimeter associated with construction activities at the new Denver International Airport is contributing to higher particulate levels at the RMA eastern boundary. The CAQMMP will continue to evaluate these TSP impacts, as well as the impacts of other potential air pollutants from the new airport.

In addition to local, off-post, and remediation source influences, seasonal and climatological conditions also influenced the data reported. Although some of these effects can be identified in the long term database, local and unique meteorological events also have overriding influences. Table 4.2-7 shows seasonal TSP results (arithmetic average and 24-hour maximum concentrations) for each of the RMA monitoring sites. The highest average TSP concentrations occurred in the summer and fall, the lowest in spring, and moderate levels occurred in winter. At AQ1, AQ2, and AQ5 on the west, northwest, and southern boundaries (which are closest to metropolitan Denver influences), the highest concentrations occurred in the summer or winter, while the interior monitoring sites experienced markedly higher average TSP concentrations during the summer period only (excluding Basin F impacts at sites AQ10 and AQ11). Highest

Table 4.2-7 Combined Seasonal Total Suspended Particulate (TSP) Concentrations for FY88 to FY92 (μg/m^3)

	Fall	Winter	Spring	Summer
Arithmetic Mean				
AQ1	60	55	42	53
AQ2	78	60	52	73
AQ3	43	32	34	54
AQ4	45	34	38	56
AQ5	45	53	37	44
AQ5B	43	43	35	45
AQ6	39	36	46	57
AQ7	46	38	35	45
AQ8	42	36	36	50
AQ9	40	31	34	44
AQ10	66	45	37	60
AQ11	81	76	49	63
AQ12	49	47	38	52
SQ1	56	37	46	54
SQ2	49	31	44	55
Seasonal Average	52	44	40	54
24-Hour Maximum				
AQ1	134	179	88	184
AQ2	162	198	118	207
AQ3	98	113	95	194
AQ4	79	102	80	171
AQ5	96	183	94	170
AQ5B	93	172	86	181
AQ6	84	143	396	321
AQ7	91	156	86	180
AQ8	116	130	99	188
AQ9	85	127	96	164
AQ10	279	175	122	252
AQ11	542	738	247	388
AQ12	165	467	238	590
SQ1	64	42	59	94
SQ2	104	44	120	116
Seasonal Maximum	542	738	396	590

μg/m^3 - Micrograms per cubic meter

seasonal average concentrations occurred during the fall at the perimeter sites, AQ1 and AQ2. Metropolitan Denver influences upon RMA were greatest in the fall and winter during intense inversion periods.

Seasonal summary data also highlight the unique influences of remediation activity at sites AQ10, AQ11, and AQ12. For example, AQ11 experienced especially high concentrations during Basin F cleanup work on several winter days, including a maximum report concentration of 738 $\mu g/m^3$. Station AQ12 was directly impacted by Borrow Pit activity during the summer of FY88 (maximum of 590 $\mu g/m^3$), resulting in a high overall summer seasonal TSP concentration at this station. During FY90, construction activities at the Lower Derby Lake spillway resulted in very high concentrations during spring and summer months at AQ6, downwind from the activity. The highest seasonal concentrations at this site occurred during spring and summer of FY90. The anomalously high value of 388 $\mu g/m^3$ at AQ11 on September 9, 1991 contributed to higher summer seasonal concentrations during FY91 as compared to previous post-remedial phases. No anomalously high values occurred at any of the stations during FY93.

Rather than identifying strong seasonal trends, these data confirm the overriding influence of individual source impacts and meteorological events. As the database continues to expand, real trends in seasonal impacts may become more apparent. Also, as the effect of individual events are further minimized, higher TSP concentrations are anticipated at the perimeter stations close to metropolitan Denver, especially at AQ1 and AQ2, during the fall and winter periods. Also, increasing traffic and industrial activity resulting from Denver International Airport operations may have a significant influence at AQ4 in the future.

4.2.4 Denver Metropolitan Area TSP Influences

4.2.4.1 Denver FY93 Results

RMA activities were not the only contribution to TSP concentrations that influenced RMA and adjacent areas as evident from previous assessments. The 1986-1987 Remedial Investigation study clearly established that prior to remediation, TSP values were highest at the perimeter

stations and lowest in the interior, suggesting that the principal long-term major sources in the area were the industrial or transportation activities of metropolitan Denver. The Basin F Remediation Program temporarily altered this situation at several sites in the interior of RMA; however, metropolitan Denver sources were still a major contributor.

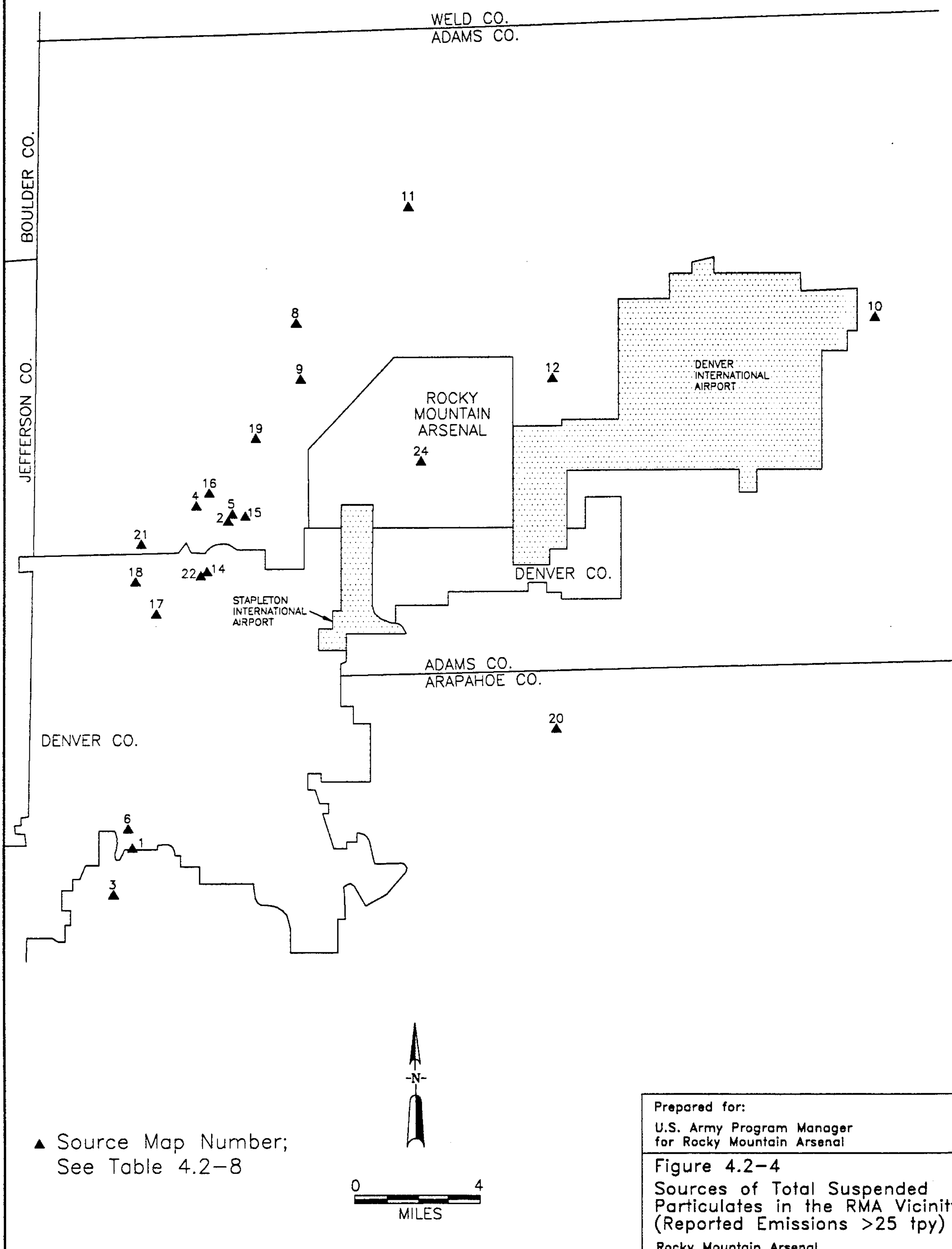
Table 4.2-8 shows the major stationary sources and updated emission inventory with TSP emission rates of 25 tpy or more surrounding RMA. Several of the sources are located within 2 miles of RMA to the west and southwest as shown in Figure 4.2-4, and contribute a large portion of the total TSP emissions for Adams, Arapahoe, and Denver counties (CDH 1993). Compared to these major TSP sources, RMA accounts for a small fraction of the total TSP emissions. In addition to these external stationary sources, dust from vehicle traffic and off-road sources contributes greatly to the TSP concentrations.

Table 4.2-9 is a summary of Denver metropolitan area TSP data measured concurrently with the FY93 program, as well as with previous remediation and post-remediation phases; because of the decrease in CDH emphasis on TSP, several Denver area TSP monitoring sites have been discontinued during this period. Figure 4.2-5 shows the geographic distribution of TSP geometric mean levels across the metropolitan area, including RMA, for FY93. The highest levels were in the downtown area at the CAMP station (2105 Broadway), where TSP concentrations have exceeded the ambient air quality primary and secondary standards for at least the past 15 years. As shown in Table 4.2-9, the annual geometric mean frequently exceeded 100 $\mu g/m^3$ and the 24-hour maximum concentration has reached levels of 500 $\mu g/m^3$ to 600 $\mu g/m^3$ depending upon the intensity of specific inversion episodes. The highest level in the last 6 years occurred on December 8, 1992, when 610 $\mu g/m^3$ was measured at the CAMP station. This episode was heaviest in the downtown section of the city but was distributed across the metropolitan area as shown in Figure 4.2-6. Although RMA TSP data are suspect on this date, the mean concentration of 18 nonvalidated observations was 115 $\mu g/m^3$ with a maximum measurement of 179 $\mu g/m^3$ at the western perimeter.

Table 4.2-8 Sources of Total Suspended Particulates in the Vicinity of Rocky Mountain Arsenal (25 tons per year [tpy] or more)

Facility	City (Source)	Update Year	Map No.	Estimate (tons per year)
Kiewit Western	Portable Source	90	1	1830.2
Conoco Inc. – Denver Refinery	Commerce City	91	2	465.0
Denver Metals	Denver	90	3	336.1
Public Service Company – Cherokee	Denver	91	4	254.1
Colorado Refining Company/Total Petroleum	Commerce City	91	5	174.2
Public Service Company – Arapahoe	Denver	91	6	94.4
Waste Management of Colo-Denver Arapahoe	Aurora	92	7	72.4
Cooley Gravel Co., 88th & Riverdale Rd.	No city name	89	8	69.9
Purina Mills, Inc. – Henderson Mill	Henderson	91	9	66.4
Centennial Materials – Thornburg	Bennett	91	10	65.4
Cooley Gravel	Brighton	92	11	63.5
BFI – Tower Landfill	Commerce City	92	12	57.5
Bennett Sand and Gravel Inc.	Bennett	92	13	50.2
Ralston Purina Company Pet Food Plant	Denver	92	14	40.8
Fast Construction Company, 64th and Steel	Commerce City	90	15	32.4
Conagra	Adams County	91	16	31.2
Mountain Cement Co., 1630 35th Street	Denver	89	17	29.0
Brannan S&G	Denver	90	18	28.8
Bituminous Roadways of Colorado, Inc.	Commerce City	92	19	28.7
Buckley Air Force Base – Colorado Air National Guard	Aurora	91	20	27.3
Owens Corning	Denver	92	21	26.5
Lightweight Materials, Inc.	Denver	92	22	26.5
Highway 36 Land Dev–BFI Sec 25 & 36 T3S R15	Broomfield	90	23	26.2
Rocky Mountain Arsenal	Commerce City	92	24	1.1

Source: EISPS inventory from CDH, 1993.



▲ Source Map Number;
See Table 4.2-8

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Figure 4.2-4
Sources of Total Suspended Particulates in the RMA Vicinity (Reported Emissions >25 tpy)

Rocky Mountain Arsenal
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Table 4.2-9 Denver Metropolitan Area Total Suspended Particulates ($\mu g/m^3$)

Station	Phase 1	Phase 2 Stage 1	Phase 2 Stage 2	Phase 3	Phase 4 (FY90)	Phase 5 (FY91)	Phase 6* (FY92)	Phase 7 (FY93)
Geometric Means								
Adams City	87.3	103.0	61.2	71.0	66.8	73.0	–	77.0
414 14th Street	83.7	137.4	–	–	–	–	–	–
CAMP/2105 Broadway	107.9	192.2	132.2	98.9	100.8	109.6	120.0	113.7
1050 S. Broadway	74.1	135.2	93.7	63.4	66.6	52.4	–	76.5
208 3rd Street	62.9	62.7	57.0	90.2	–	–	–	–
4857 S. Broadway	64.4	84.9	–	–	–	–	–	–
24-Hour Maximum Values								
Adams City	283.0	244.0	85.0	131.0	206.0	228.0	268.0	319.0
414 14th Street	242.0	183.0	–	–	–	–	–	–
CAMP/2105 Broadway	260.0	472.0	256.0	149.0	363.0	563.0	379.0	610.0
1050 S. Broadway	162.0	278.0	162.0	100.0	287.0	177.0	–	212.0
208 3rd Street	153.0	179.0	144.0	385.0	–	–	–	–
4857 S. Broadway	152.0	94.0	–	–	–	–	–	–

* Phase 6 data taken from incomplete record
$\mu g/m^3$ - Micrograms per cubic meter
– Samples not collected or data not available

Phase 1 is from March 22 to December 12, 1988
Phase 2, Stage 1 is from December 13, 1988 to February 15, 1989
Phase 2, Stage 2 is from February 16 to May 5, 1989
Phase 3 is from May 6 to September 30, 1989
Primary 24-hour standard for Colorado is 260 $\mu g/m^3$ (suspended in August 1993 for one year)
Primary annual (geometric mean) standard for Colorado is 75 $\mu g/m^3$ (suspended in August 1993 for one year)

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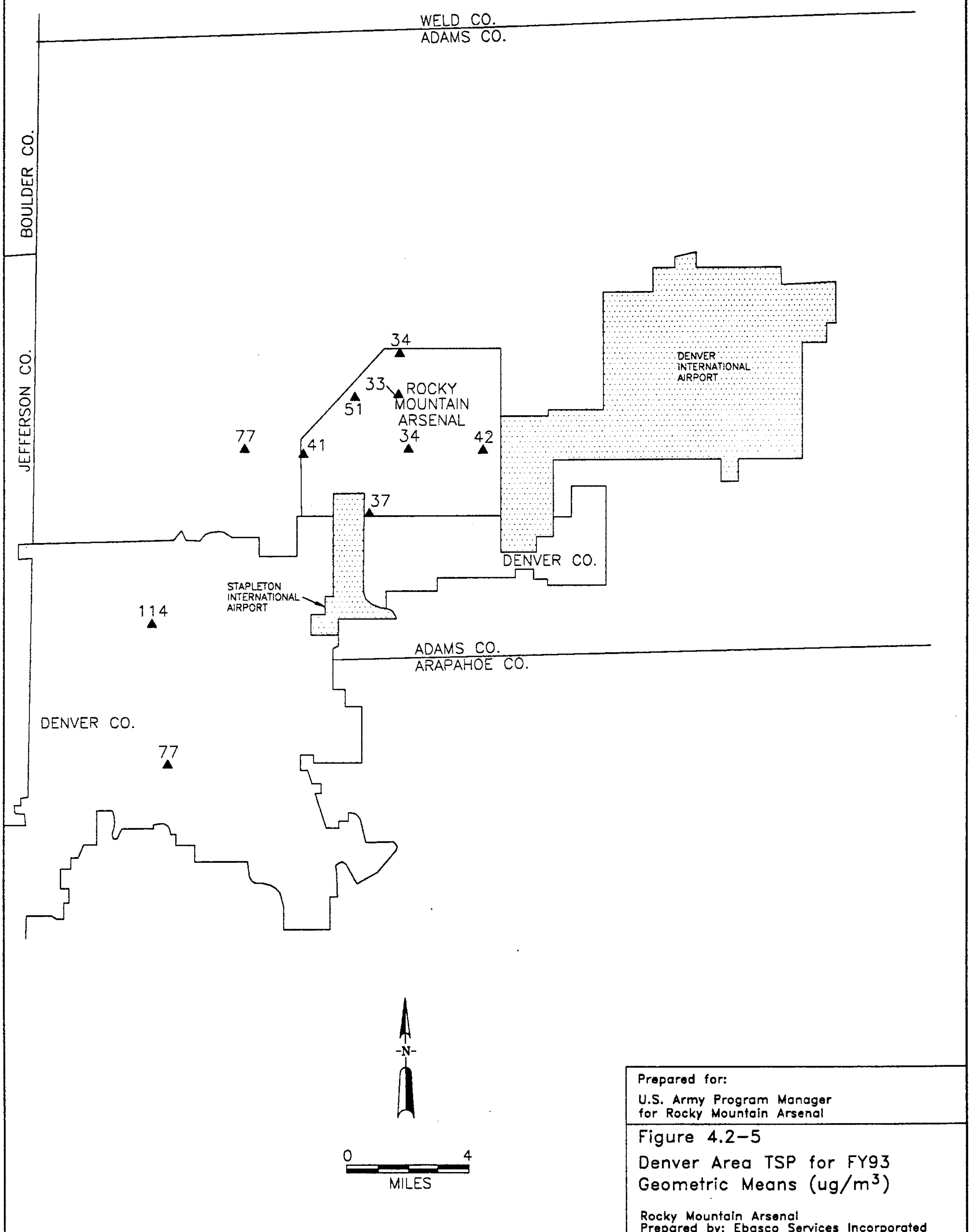

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Figure 4.2-5

Denver Area TSP for FY93
Geometric Means (ug/m^3)

Rocky Mountain Arsenal
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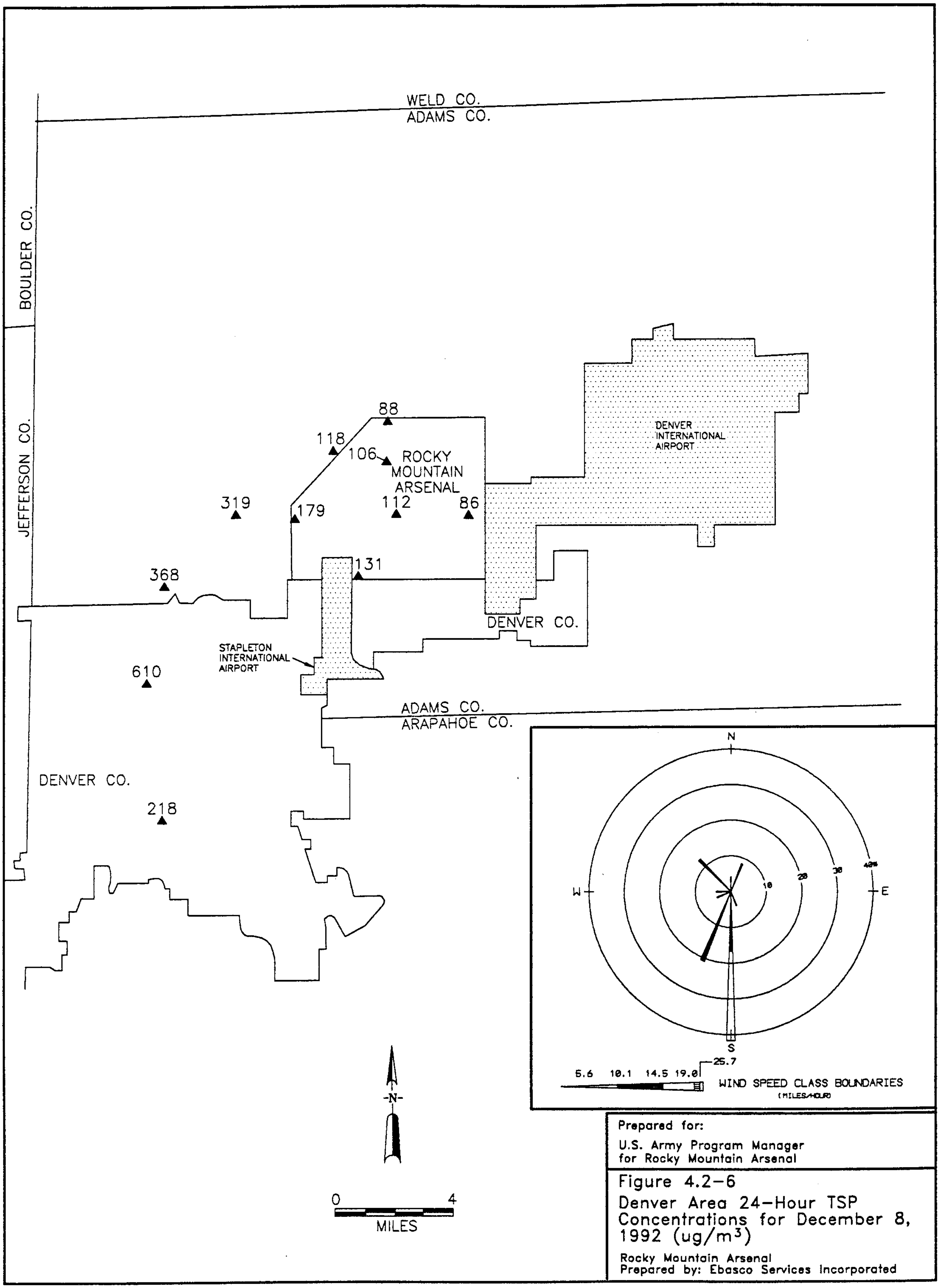

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Figure 4.2-6
Denver Area 24-Hour TSP Concentrations for December 8, 1992 (ug/m^3)

Rocky Mountain Arsenal
Prepared by: Ebasco Services Incorporated

The upper air sounding on this date (0000Z, 8 December 1993) at Stapleton Airport is shown in Figure 4.2-7. This is the afternoon sounding (1700MST) and indicates that the inversion did not "break" during the day. The inversion extended to 1,500 feet above ground level and, in fact, did not break for several days. Winds were light (under 5 mph) and primarily from the south (see wind rose in Figure 4.6-6). Temperatures remained below freezing for several days. This episode was associated with high levels of PM-10, metals, VOCs, and gaseous criteria pollutants at RMA and will be discussed further in appropriate sections of this report.

The December 8, 1992 episode is typical of occasional fall and winter occurrences when, under intense inversion conditions, high TSP concentrations from the general metropolitan area have been transported to RMA. This episode, however, was especially severe.

As a general rule, mean concentrations decrease from the center of Denver and are typically about 50 percent lower in the outlying suburbs, including RMA. Prior to Basin F remediation activity in 1986-1987, the average concentration at RMA for all sites was 40 $\mu g/m^3$. The boundary sites, AQ1 and AQ2, averaged 54 $\mu g/m^3$ and were comparable to other suburban measurements, whereas the interior RMA sites averaged 38 $\mu g/m^3$ (see Table 4.2-5). This trend was temporarily altered during Basin F remediation activities. However, during the FY93 post-remedial period, the average TSP concentration for all CMP sites was 34 $\mu g/m^3$, with the boundary sites averaging 42 $\mu g/m^3$ and the interior sites averaging 32 $\mu g/m^3$. These results are similar to the pre-remedial monitoring results at RMA.

One important difference between high TSP values measured in metropolitan Denver and those at RMA is that those experienced in metropolitan Denver were frequently associated with high pollution episodes in which industrial and vehicle traffic emissions were trapped under a blanketing inversion that spread across the area. In these cases, winds were generally light to moderate. Occasionally, these metropolitan Denver impacts extended to the vicinity of RMA; however, during remedial operations at RMA, higher concentrations were invariably associated with strong wind gusts that lifted dirt that had been loosened by handling.

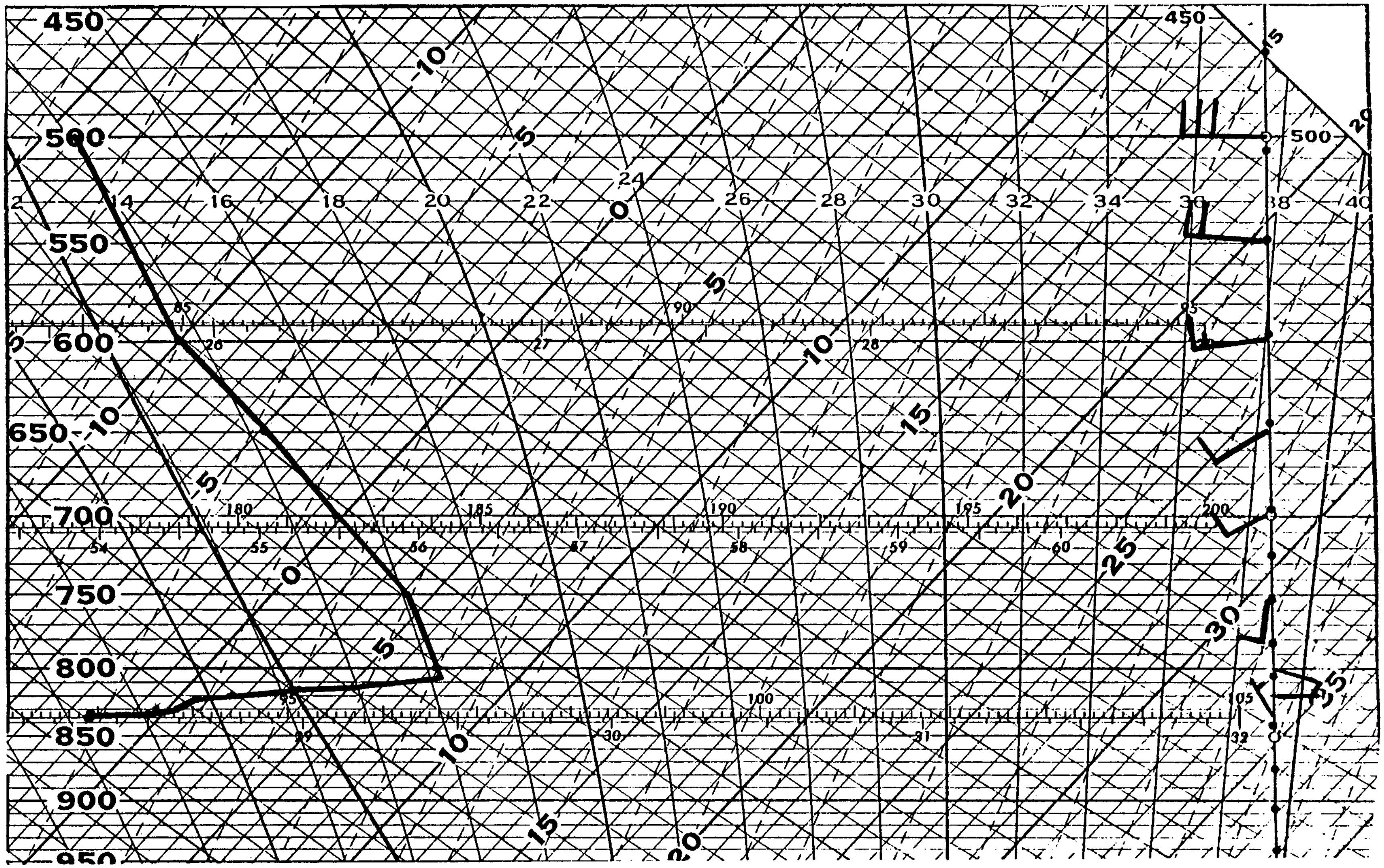

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Figure 4.2-7

Denver Upper-Air Sounding
for 12/7/92 1700 MST

Rocky Mountain Arsenal
Prepared by: Ebasco Services Incorporated

4.2.5 Analysis Implications for Mitigation and Controls

The general results of these investigations indicate that many of the RMA sources were localized and that although very high concentrations were frequently measured adjacent to remedial activities, concentrations decreased significantly with distance from the source. Consequently, those sources located in the RMA interior were less likely to cause impacts off post, while those sources closer to the boundaries were more likely to cause temporary impacts at the boundary when strong or gusty winds were directed from the source to the boundary.

Also, certain atmospheric conditions and other factors that vary diurnally can spread pollutants greater distances from the disturbing source. The ongoing CAQMMP and summarized data results, with analyses of probable causative factors, form the basis for deciding appropriate mitigating actions. For example, when the monitoring data show excessive TSP concentrations, chemical stabilizers, covers, reseeding, and landscaping can be used over sensitive areas, as in the case of Basins F and A. Dirt excavation, hauling, and unloading can be minimized during periods of high winds and poor dispersion potential, particularly when transport of the resultant airborne dust would be towards nearby boundaries. Surface watering during these operations would also help minimize the generation of dust. This practice has been applied periodically and as appropriate at RMA.

4.2.6 Summary

TSP concentrations observed at RMA can be attributed to two principal sources: (1) the influx of industrial or urban traffic emissions from metropolitan Denver, and (2) remedial activity producing wind-blown dust, usually during high wind episodes. A noticeable increase in TSP concentrations at sites adjacent to or directly downwind from construction work, primarily at Basin F, occurred during the FY88 and FY89 CMP monitoring periods because of increased remedial activity at RMA. However, the impacts from sources originating within RMA were localized and decreased rapidly with distance from the source. From FY90 through FY93, after

termination of the Basin F cleanup program, TSP concentrations downwind from Basin F decreased significantly.

4.3 PARTICULATE MATTER LESS THAN 10 MICROMETERS

4.3.1 PM-10 Monitoring Program

Respirable particulate matter, designated PM-10, are those particles in air with aerodynamic diameters less than 10 micrometers (μm). These particles are typically small enough to be inhaled deep within the lungs. As a continuation of the ongoing CAQMMP, PM-10 was monitored at twelve individual sites (AQ1, AQ2, AQ3, AQ4, AQ5, AQ6, AQ8, AQ9, AQ10, FC1, SQ1, and SQ2) during the FY93 monitoring period. A collocated monitor at Site AQ5 (designated as AQ5C) was also a continuation from the previous monitoring years. Because of the increasing PM-10 emphasis, three additional monitoring sites AQ4, AQ6, and AQ8 were established in FY93. A summary of sampling frequency and data recovery for FY93 PM-10 monitoring is displayed in Table 4.3-1. The discussion in Section 4.2.1 pertaining to TSP filters also applies to PM-10. Samples collected prior to February 1, 1993 are considered suspect and are not included in the annual summaries. Again, all PM-10 FY93 measurements taken during the year are provided in Appendix B, including the data prior to February 1; some of these data may be reliable and may be considered for analysis on a case-by-case basis.

The average (arithmetic mean) and 24-hour maximum concentrations for the CAQMMP FY93 PM-10 program are presented in Tables 4.3-2 and 4.3-3, respectively. As shown in Section 2, Table 2.1-1, the PM-10 federal and state standards are arithmetic mean values of 50 $\mu g/m^3$ on an annual basis, and 150 $\mu g/m^3$ for a 24-hour period. For FY93, PM-10 did not exceed either the annual or 24-hour ambient air quality standards at any of the monitored sites at RMA.

Highest PM-10 concentrations were measured at the RMA boundaries. AQ1 measured the highest annual average concentration of 25 $\mu g/m^3$ during FY93. AQ2, at the northwestern boundary and closest to Commerce City traffic, also measured an annual average of 25 $\mu g/m^3$. The highest 24-hour levels were 86 $\mu g/m^3$ at AQ1 and 71 $\mu g/m^3$ at AQ2 during FY93. AQ4,

Table 4.3-1 Summary of Particulate Matter less than 10 Micrometers Monitoring for FY93

Station	Samples Scheduled	Samples Collected	Valid Samples	Field % Recovery	Overall % Recovery
AQ1	61	59	38	97	62
AQ2	61	59	36	97	59
AQ3	61	60	38	98	62
AQ4	61	58	38	95	62
AQ5	61	60	35	98	57
AQ6	61	60	36	98	59
AQ8	61	51	36	84	59
AQ9	61	60	36	98	59
AQ10	61	59	39	97	64
FC1	31	30	21	97	68
SQ1	61	61	38	100	62
SQ2	61	59	38	97	62
Duplicate	61	60	35	98	57
Overall	763	736	464	96	61

% Percent

Table 4.3-2 Particulate Matter less than 10 Micrometers (PM-10) Sampling Results for FY93 Arithmetic Mean Concentration ($\mu g/m^3$)

	AQ1	AQ2	AQ3	AQ4	AQ5	AQ6	AQ8	AQ9	AQ10	SQ1	SQ2	FC1
October*												
November*												
December*												
January*												
February	56	46	32	29	44	31	33	33	30	35	34	32
March	35	22	20	19	29	16	31	16	21	25	16	23
April	10	11	11	14	8	11	26	5	11	12	10	6
May	25	22	18	23	20	14	18	16	18	18	17	14
June	21	27	19	22	17	16	17	17	17	20	18	16
July	20	31	19	36	17	17	18	25	16	20	20	16
August	24	23	19	31	18	18	19	21	19	20	19	20
September	22	26	20	24	18	19	19	18	18	20	19	17
Annual	25	25	19	24	21	16	22	18	18	20	18	18

* - As noted in text, data for these months were not considered sufficiently reliable to include in the summaries.

$\mu g/m^3$ - Micrograms per cubic meter

Table 4.3-3 Particulate Matter less than 10 Micrometers (PM-10) Sampling Results for FY93
24-Hour Maximum Concentration ($\mu g/m^3$)

	AQ1	AQ2	AQ3	AQ4	AQ5	AQ6	AQ8	AQ9	AQ10	SQ1	SQ2	FC1
October*												
November*												
December*												
January*												
February	74	71	41	34	66	39	42	40	44	50	46	41
March	86	29	29	35	66	26	64	36	39	50	36	32
April	15	20	22	40	14	19	77	7	22	24	24	9
May	38	30	26	35	25	23	25	23	25	29	25	19
June	30	51	30	41	27	27	28	28	31	40	31	27
July	30	36	25	55	26	23	25	44	25	25	27	21
August	30	37	27	48	22	21	23	27	24	25	24	23
September	30	40	28	32	22	27	29	26	25	25	25	22
Annual	86	71	41	55	66	39	77	44	44	50	46	41

* - As noted in text, data for these months were not considered sufficiently reliable to include in the summaries.
$\mu g/m^3$ - Micrograms per cubic meter

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which is a new PM-10 monitoring site at the eastern boundary, and is closest to increasing traffic from the Denver International Airport development activities, measured an arithmetic mean value of 24 μg/m^3 (the third highest) and a maximum 24-hour value of 55 μg/m^3. It is interesting that all of the other PM-10 monitoring stations measured arithmetic mean concentrations ranging from 16 to 21 μg/m^3, suggesting little variation in PM-10 levels except at the boundary locations. A summary of annual arithmetic mean PM-10 concentrations for FY93 is presented graphically in Figure 4.3-1. The FY93 PM-10 annual arithmetic mean values were lower than those obtained during the FY92 monitoring period. A likely explanation for this is that the FY93 data do not include several fall and winter months when static electricity problems with the PM-10 filters made these data suspect. A qualitative analysis of the data results shown in Appendix B indicate occasional moderate to high PM-10 levels that also correspond to high PM-10 levels in metropolitan Denver and that were associated with winter inversion episodes. This will be discussed further in Section 4.3.3 in connection with the December 8, 1992 intense inversion episode.

4.3.2 Basin F PM-10 Impacts

PM-10 was not monitored in close proximity to Basin F during the Basin F remediation program or the follow-on IRA-F program. With increasing emphasis on respirable particles less than 10 micrometers, PM-10 monitoring at RMA has increased from three stations in 1987 to fifteen stations in FY93, including FC1 which is directly downwind from the remediated Basin F. Table 4.3-4 shows annual arithmetic mean and 24-hour ambient PM-10 concentrations for the various phases of the Basin F assessment. As noted, during the early remediation activity, there were no close-in PM-10 monitors, and it is difficult to discern significant increases at the several (more distant) stations that were sampled. Earlier CMP reports have suggested that the impact on PM-10 levels from remediation activity was less than from the larger total suspended particulates (RLSA 1991). This was based on an assessment of the more distant PM-10 monitoring stations (AQ1, AQ2, AQ3, AQ5 and AQ6). Under recent revisions to the CAQMMP, it is anticipated that PM-10 monitoring will be an integral part of all future remediation monitoring programs.

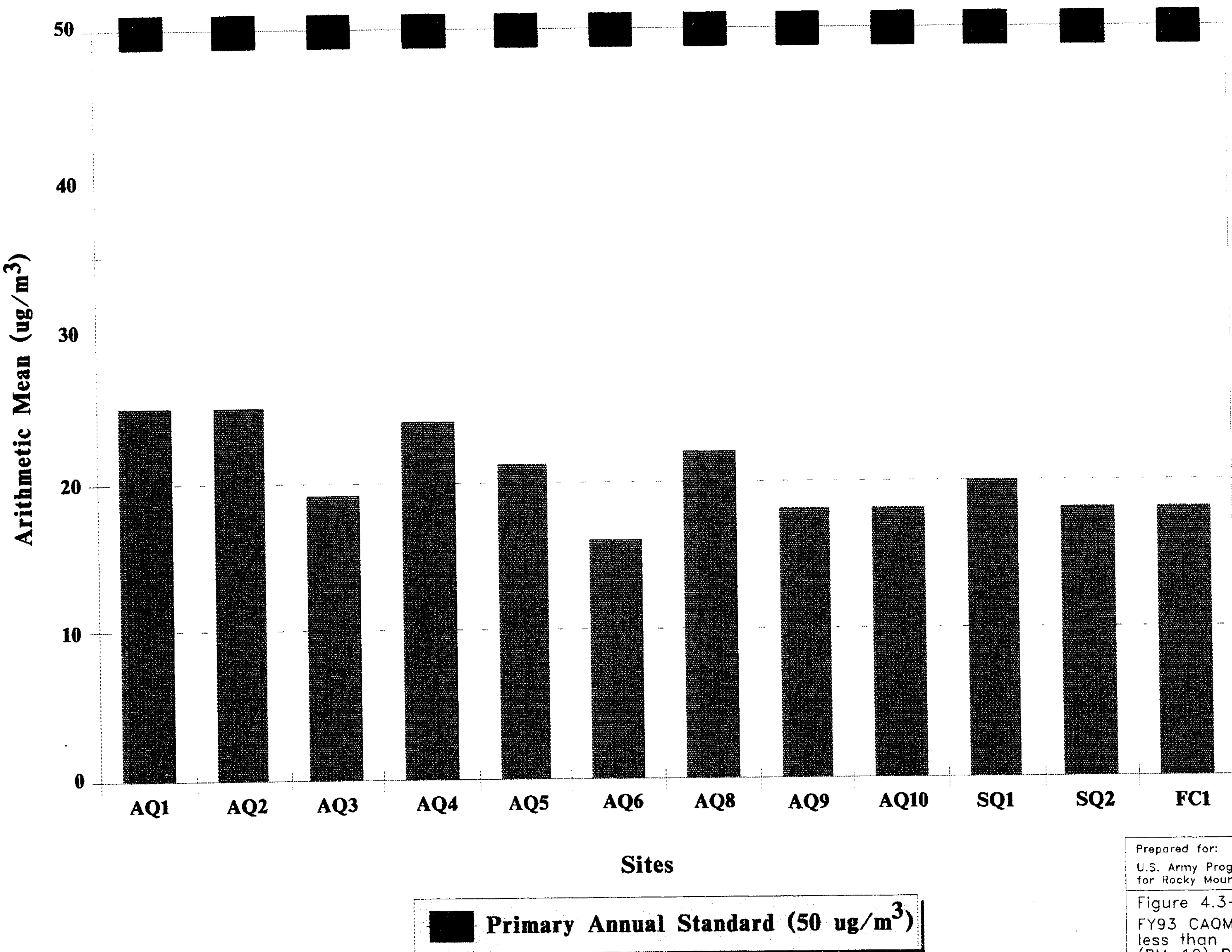

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Figure 4.3-1
FY93 CAQMMP Particulate Matter less than 10 Micrometers (PM-10) Results

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Table 4.3-4 Particulate Matter less than 10 Micrometers (PM-10) Results for Phases 1 through 7 ($\mu g/m^3$)

Phase	AQ1	AQ2	AQ3	AQ5	AQ9	AQ10[c]	SQ1	SQ2	FC1
Arithmetic Mean[a]									
Pre-Rem		36		33	18				
Phase 1	39	30	30	22	22				
Phase 2 Stage 1	52	36	30	35	27				
Phase 2 State 2	31	22	19	21	17				
Phase 3	24	26	21	21	20				23
Phase 4	23	25	20	21	19	36			24
Phase 5 Stage 1	*	*	*	*	*	*	*	*	26
Phase 5 Stage 2	26	25	18	20	20	21	23	23	18
Phase 6	30	30	22	24	24	26	26	26	27
Phase 7	25	25	19	21	18	18	20	18	18
24- Hour Maximum[b]									
Pre-Rem		94		90	36				
Phase 1	77	72	60	47	51				
Phase 2 State 1	168	105	94	116	94				
Phase 2 Stage 2	56	33	30	37	27				
Phase 3	39	46	37	33	36				35
Phase 4	72	81	72	66	71	90			102
Phase 5 Stage 1	*	*	*	*	*	*	*	*	84
Phase 5 Stage 2	70	77	48	43	92	48	43	47	47
Phase 6	92	76	41	52	53	43	56	50	52
Phase 7	86	71	41	66	44	44	50	46	41

a - Annual arithmetic mean standard is 50 $\mu g/m^3$.
b - 24-Hour Maximum standard is 150 $\mu g/m^3$.
c - AQ10 was installed in the northwest quarter of Section 1 on September 5, 1990.
* - No samples collected, contract lapse.
$\mu g/m^3$ - Micrograms per cubic meter

Note: Pre-Rem refers to data collected during the Air Remedial Investigation (Environmental Science & Engineering, Inc., 1988).

Phase 1 is from March 22 to December 12, 1988.
Phase 2, Stage 1 is from December 13, 1988 to February 15, 1989.
Phase 2, Stage 2 is from February 16, 1989 to May 5, 1989.
Phase 3 is from May 5 to September 30, 1989.
Phase 4 is from October 1, 1989 to September 30, 1990 (FY90).
Phase 5, Stage 1 is from October 1, 1990 to January 23, 1991.
Phase 5, Stage 2 is from January 24, 1991 to September 30, 1991 (FY91).
Phase 6 is from October 1, 1991 to September 30, 1992 (FY92).
Phase 7 is from October 1, 1992 to September 30, 1993 (FY93).

With respect to post-remediation PM-10 impacts at Basin F, FY93 data from FC1, directly downwind from the remediated basin, indicate an annual arithmetic mean of 18 $\mu g/m^3$ and a 24-hour maximum value of 41 $\mu g/m^3$, among the lowest levels at RMA.

4.3.3 Metropolitan Denver PM-10 Data

As in the case of TSP, PM-10 concentrations were higher in metropolitan Denver than they were at RMA. The distribution of PM-10 data across metropolitan Denver and the prevailing south and south-southwest wind flow across the area suggests that there is an influx of PM-10 into RMA from the Denver area. PM-10 annual arithmetic mean and 24-hour maximum concentrations for Denver throughout the CMP/CAQMMP history, including FY93, are shown in Table 4.3-5. Note the number of additional PM-10 monitoring stations that have been added by CDH in 1993, reflecting the increasing emphasis on this parameter. Figure 4.3-2 shows the distribution of PM-10 annual average values across metropolitan Denver and RMA for the FY93 period. The highest annual average was at the "Gates Rubber" site at 1050 S. Broadway, 40.7 $\mu g/m^3$; however, comparable levels were also measured at the CAMP station at 21st Street and Broadway, and also at the Adams City 72nd Street site. RMA averages were considerably lower, but did not include data from November 1992 through January 1993. It is also noted that the highest PM-10 levels occurred at RMA boundaries.

Maximum 24-hour PM-10 concentrations were 183 $\mu g/m^3$ at Adams City and 175 $\mu g/m^3$ at the Gates site. These occurred on December 8, 1992 as did all 24-hour maximum concentrations at other individual sampling sites both in Denver and at RMA. This was also the day that the highest concentrations of TSP, most of the metals, and most of the VOCs occurred. Figure 4.3-3 shows the distribution of PM-10 over Denver and RMA on December 8 (note, however, that RMA PM-10 data could not be validated on this date). See Section 4.2.4 in the TSP section for a further discussion of this event.

Table 4.3-5 Denver Metropolitan Area Particulate Matter of less than 10 Micrometers (PM-10) ($\mu g/m^3$)

Station	Phase 1	Phase 2 Stage 1	Phase 2 Stage 2	Phase 3	Phase 4 (FY90)	Phase 5 (FY91)	Phase 6 (FY92)	Phase 7 (FY93)
Arithmetic Means[a]								
Adams City	40.5	72.8	27.2	31.2	32.1	38.7	39.8	39.5
8101 Ralston	27.2	36.0	27.2	34.8	*	*	*	*
1633 Florence	26.7	31.2	26.3	26.0	24.1	23.1	*	*
414 14th Street	30.6	71.7*	39.3*	32.2	31.1	32.9	*	*
CAMP/2105 Broadway	28.7	45.1	37.2	27.4	27.3	31.6	29.3	38.4
1050 S. Broadway	31.2	49.7*	35.2	29.7	32.1	30.8	32.8	40.7
4857 S. Broadway	23.1	39.9	27.4	23.6	22.0	13.1	21.0	29.8
24-Hour Maximum Values[b]								
Adams City	103.0	145.0	36.0	50.0	94.0	106.0	183	183
8101 Ralston	56.0	57.0	59.0	78.0	*	*	*	*
1633 Florence	94.0	77.0	56.0	49.0	84.0	64.0	*	*
414 14th Street	66.0	123.0	59.0	54.0	118.0	67.0	*	*
CAMP/2105 Broadway	123.0	154.0	62.0	45.0	82.0	95.0	160	160
1050 S. Broadway	68.0	64.0	57.0	51.0	118.0	70.0	176	176
4857 S. Broadway	48.0	103.0	44.0	39.0	49.0	29.0	105	105

* Incomplete data set or samples no longer collected at this location

a Annual arithmetic mean standard is 50 $\mu g/m^3$
b Maximum 24-hour standard is 150 $\mu g/m^3$
$\mu g/m^3$ Micrograms per cubic meter

Phase 1 is from March 22 to December 12, 1988
Phase 2, Stage 1 is from December 13, 1988 to February 15, 1989
Phase 2, Stage 2 is from February 16 to May 5, 1989
Phase 3 is from May 6 to September 30, 1989

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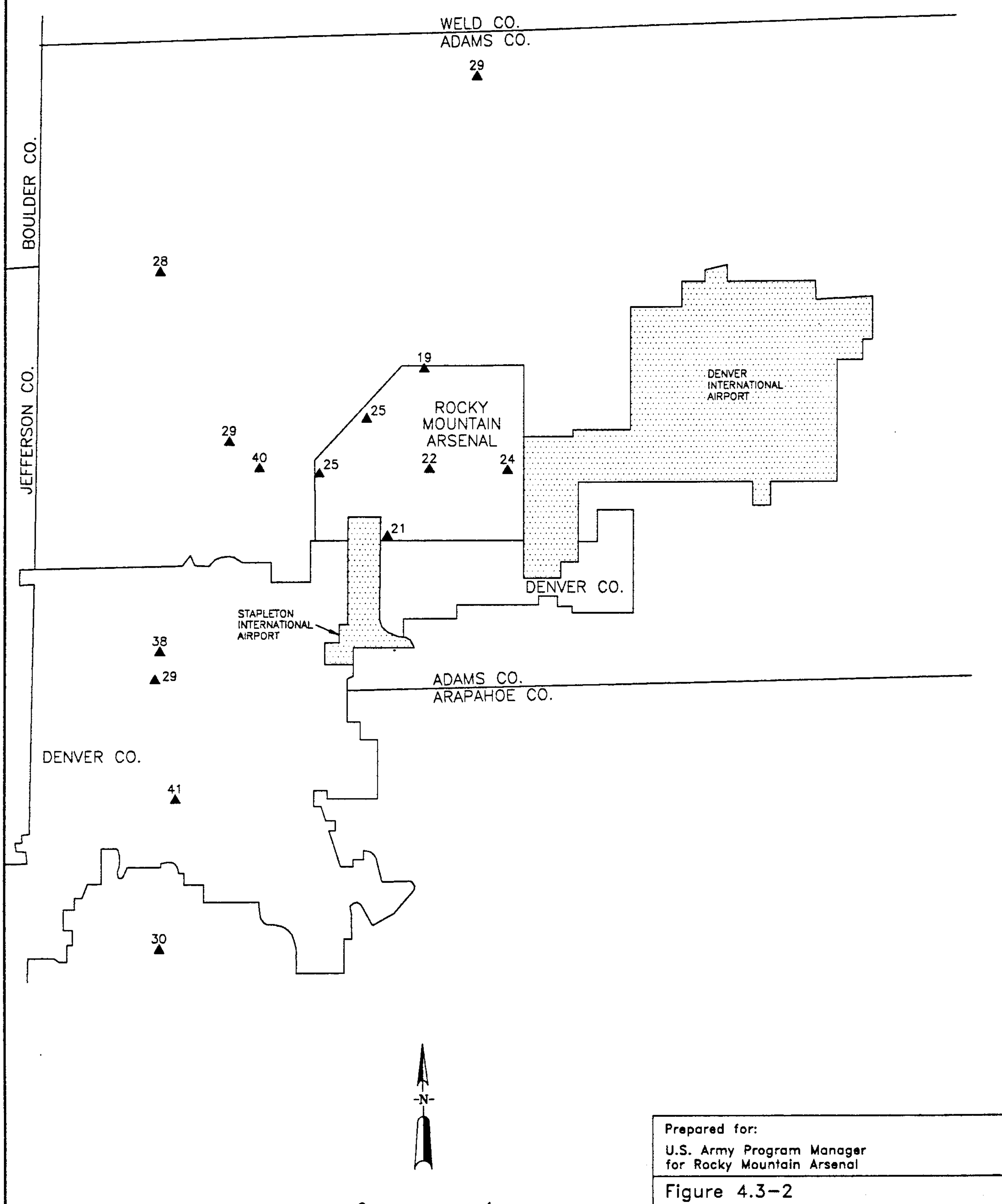

Prepared for:

U.S. Army Program Manager
for Rocky Mountain Arsenal

Figure 4.3-2

Denver Area PM-10 Concentrations for FY93 Arithmetic Means (ug/m^3)

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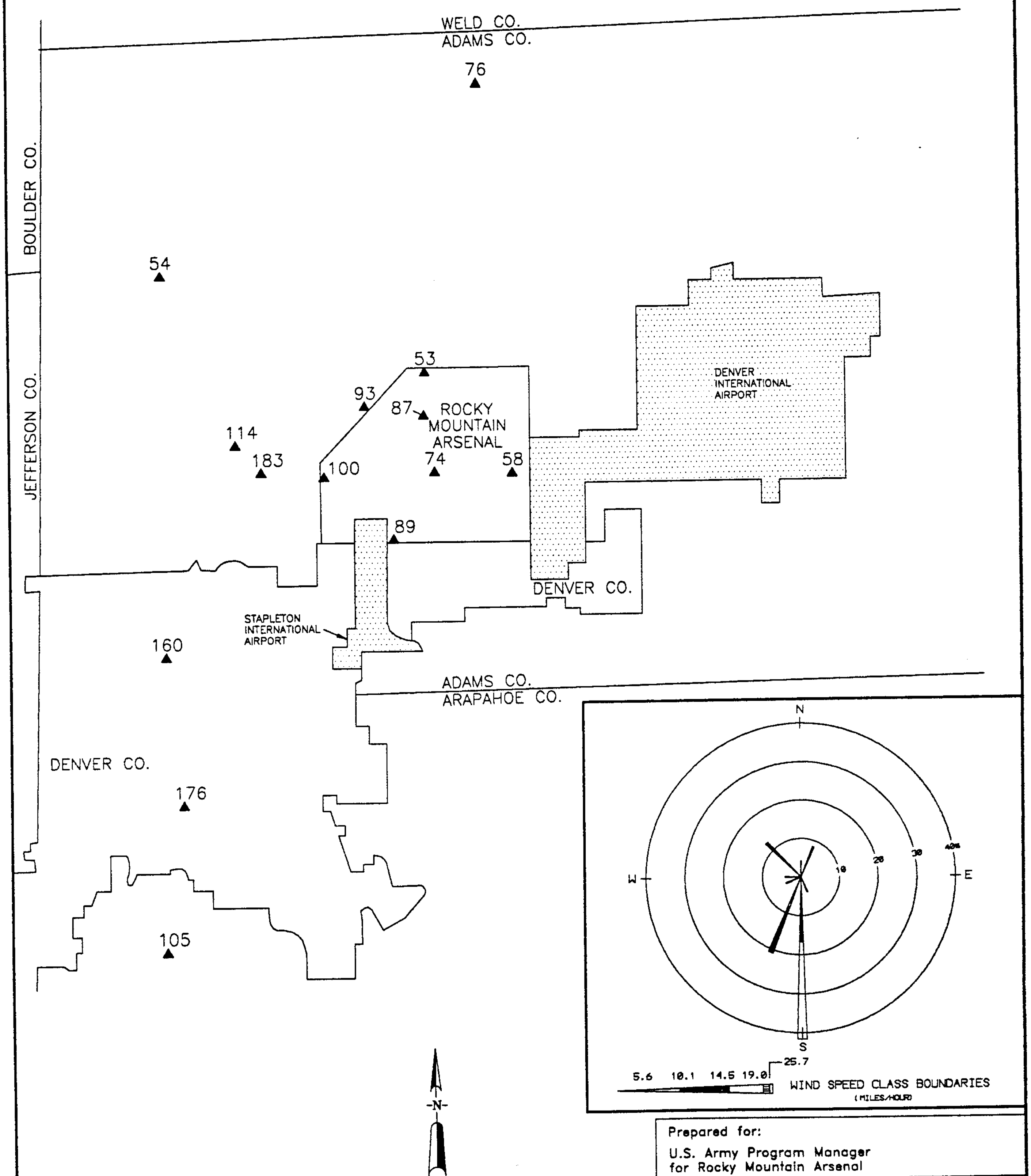

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U.S. Army Program Manager
for Rocky Mountain Arsenal

Figure 4.3-3
Denver Area 24-Hour PM-10 Concentrations for December 8, 1992 (ug/m^3)

Rocky Mountain Arsenal
Prepared by: Ebasco Services Incorporated

4.3.4 Summary of PM-10 Analysis

Strong gusty winds appeared to contribute to higher PM-10 values at RMA, but to a much lesser extent than for TSP. The highest PM-10 readings were observed during strong atmospheric inversion conditions over metropolitan Denver. There were no violations of the annual or 24-hour PM-10 standards during FY93 at RMA. As in the case of TSP, there were potentially two principal sources of PM-10 impacting RMA and its surroundings: (1) the influx of PM-10 emissions from metropolitan Denver, and (2) remediation activity sources at RMA, especially during high wind episodes. Unlike the trends observed in TSP concentrations, PM-10 concentration data do not indicate a detectable increase in average PM-10 levels during the remedial activity. This observation is likely the result of the lack of PM-10 monitoring stations immediately adjacent to remedial activities; nevertheless, most PM-10 remediation-generated emissions appeared to be localized and fell off significantly with distance from the activity. PM-10 sampling at RMA was increased during FY93 and will be included in the vicinity of future remedial activities. It is anticipated that these data will provide a more definitive assessment of PM-10 remediation impacts.

4.4 METALS

A total of six metallic ions were analyzed from TSP filters after the filters were weighed, including arsenic, cadmium, chromium, copper, lead, and zinc. Mercury was measured using Hydrar tubes and analyzed using the Rathje and Marcero method (Rathje and Marcero 1976).

4.4.1 Metals Monitoring Strategies

There were basically two components of the CAQMMP FY93 metals monitoring program. The first component was routine sampling every 6th day at AQ2, AQ3, AQ5, AQ5D, AQ6, AQ8, SQ1, and SQ2; every 12th day at FC1, FC2, and FC5; and monthly at FC3 and FC4. During the SQI special monitoring program, metals were also sampled every third day at SQ1, SQ2, AQ3 and AQ6. A summary of sampling frequency and data recovery for the routine monitoring program is provided in Tables 4.4-1a and 4.4-1b. It is noted that although metals analyses were obtained from TSP filters, the static electricity problems associated with TSP (and PM-10)

Table 4.4-1a Summary of Metals and Arsenic Monitoring for FY93

Station	Samples Scheduled	Samples Collected	Valid Samples	Field % Recovery	Overall % Recovery
AQ2	61	57	55	93	90
AQ3	61	58	56	95	92
AQ5	61	60	58	98	95
AQ6	61	58	56	95	92
AQ8	61	59	57	97	93
FC1	31	30	29	97	94
FC2	31	29	27	94	87
FC3	12	13	12	108	100
FC4	12	12	11	100	92
FC5	31	29	28	94	90
SQ1	61	58	56	95	92
SQ2	61	57	55	93	90
Duplicate	61	63	61	103	100
Overall	605	583	561	96	93

% - Percent

Table 4.4-1b Summary of Mercury Monitoring for FY93

Station	Samples Scheduled	Samples Collected	Valid Samples	Field % Recovery	Overall % Recovery
AQ2	61	60	59	98	97
AQ3	61	59	58	97	95
AQ5	61	61	60	100	98
AQ6	61	58	57	95	93
AQ8	61	55	54	90	89
FC1	31	32	32	103	103
FC2	31	30	30	97	97
FC3	12	13	13	108	108
FC4	12	13	13	108	108
FC5	31	32	32	103	103
SQ1	61	59	58	98	95
SQ2	61	58	58	95	95
Duplicate	61	61	58	100	95
Overall	605	591	582	98	96

% - Percent

* - Values over 100% reflect more samples taken than scheduled

analyses had no significant impact on the metals results. The second component involved high-event monitoring during specified high wind episodes (i.e., winds generally in excess of 10 mph and gusts in excess of 25 mph), or during specified contingency events. Twelve high-event episodes were conducted for the various metals components. Monitoring was conducted at various locations across RMA depending upon the meteorological conditions and selected source activities of special interest. Table 4.4-2 provides a detailed account of all metals high-event episodes including sampling dates, location, and potential source target areas; these included previously identified potential metals source areas such as Basins A and F, as well as special FY93 areas of interest such as the SQI facilities, Basin A excavation activities, Basin A soil-sifting activities, and brine loading activities at the railroad yard. In all cases, sampling was conducted for 24 hours with the exception of one 8-hour period during the soil-sifting operations. In most cases, sampling was augmented with mobile monitors to better surround the source of interest.

4.4.2 CMP FY93 Metals Monitoring Results

Average and short-term maximum concentrations of the full CAQMMP monitoring program for arsenic, cadmium, chromium, copper, lead, mercury and zinc are shown in Tables 4.4-3 and 4.4-4 with detailed sequential data shown in Appendix C. For those metals that contained both laboratory detectable and non-detectable values, average concentrations for the monitoring year were estimated by assigning a value of one-half of the detection limit to samples below the detection limit (this is shown in parentheses below the lower certified reporting limits provided in Table 4.4-3).

Results of the CAQMMP FY93 metals monitoring program were generally comparable to past CMP results. With several exceptions, metals levels were fairly uniform across RMA and for the most part were representative of their proximity to the Denver urban environment. For example, the highest annual average and 24-hour maximum concentrations for many of the metals occurred at AQ2 and AQ5 on the northwestern and southern boundaries, respectively. All maximum 24-hour concentrations were still well below concentrations measured during Basin F

Table 4.4-2 FY93 Metals High-Event Sampling Locations

Date	Target Area	Duration (Hours)	Sampling Locations
1/22/93	Basin F	1300 - 1300	AQ2, AQ3, AQ5, AQ6, FC2, FC4
3/4/93	Submerged Quench Incinerator (Baseline)	1200 - 1200	AQ2, AQ3, AQ5, AQ6, FC2, M1E, SQ1, SQ2
4/10/93	Basin A	1500 - 1500	AQ2, AQ3, AQ5, AQ6, M136E, M236W
6/12/93	Submerged Quench Incinerator (Trial Burn)	0700 - 0700	AQ3, AQ6, SQ1, SQ2, FC2, M125W
6/24/93	Basin A Excavation Activities	0900 - 0900	AQ5, AQ8, AQ9, M336E, M436W
6/30/93	Basin F	1100 - 1100	FC1, FC2, FC3, AQ11, AQ5, M226E
7/15/93	Basin A Soil Sifting	0700 - 1500 (8 hours)	AQ1, AQ4, AQ5, AQ8, AQ9, AQ10, M601N, M701N
8/29/93	Submerged Quench Incinerator	1300 - 1300	AQ3, AQ6, SQ1, SQ2, FC2, M225W
9/12/93	Basin F Waste Pile	1200 - 1200	FC2, FC3, FC4, M326E, M426S, M526SE
9/25/93	Brine Loading at Railyard	1400 - 1400	AQ1, AQ5, AQ7, M104NE, M204SE, M102W
9/28/93	Pond A Liner Cleaning	1200 - 1200	AQ2, AQ11, AQ12, FC1, FC4, FC5
9/30/93	Section 35 Excavation Activities	1200 - 1200	AQ2, AQ7, AQ9, FC3, M135N, M134E

Table 4.4-2 FY93 Mercury High-Event Sampling Locations

Date	Target Area	Duration (Hours)	Sampling Locations
1/22/93	Basin F	1300 - 1300	AQ2, AQ3, AQ5, AQ6, FC2, FC4
3/4/93	Submerged Quench Incinerator (Baseline)	1200 - 1200	AQ2, AQ3, AQ5, AQ6, FC2, SQ1, SQ2, M1E
4/10/93	Basin A	1500 - 1500	AQ2, AQ3, AQ5, AQ6, M136E, M236W
6/12/93	Submerged Quench Incinerator (Trial Burn)	0700 - 0700	AQ3, AQ6, SQ1, SQ2, FC2, M125W
6/24/93	Basin A Excavation Activities	1300 - 1300	AQ5, AQ8, AQ9, M336E, M436W
6/30/93	Basin F	1100 - 1100	FC1, FC2, FC3, FC4, AQ5, AQ11, M226E
7/15/93	Basin A Soil Sifting	0700 - 1500 (8 hours)	AQ1, AQ4, AQ5, AQ8, AQ9, AQ10, M601N, M701N
8/29/93	Submerged Quench Incinerator	1300 - 1300	AQ3, AQ6, FC2, SQ1, SQ2, M225W
9/12/93	Basin F Waste Pile	1200 - 1200	FC2, FC3, FC4, M326E, M426S, M526SE
9/25/93	Brine Loading at Railyard	1400 - 1400	AQ1, AQ5, AQ7, M104NE, M204SE, M102W
9/28/93	Pond A Liner Cleaning	1200 - 1200	AQ2, AQ11, AQ12, FC1, FC4, FC5
9/30/93	Section 35 Excavation Activities	1200 - 1200	AQ2, AQ7, AQ9, FC3, M135N, M134E

Table 4.4-3 Summary of FY93 Average Metals, Arsenic, and Mercury Concentrations (μg/m³)

Station	Cadmium	Chromium	Copper	Lead	Zinc	Arsenic	Mercury
AQ2	<0.0024 (0.0015)	<0.0123 (0.0062)	0.1017	<0.0245 (0.0152)	0.0434	<0.0008 (0.00056)	<0.2310 (0.1217)
AQ3	<0.0024 (0.0013)	<0.0123 (0.0062)	0.0816	<0.0245 (0.0126)	0.0244	<0.0008 (0.00050)	<0.2310 (0.1198)
AQ5	<0.0024 (0.0013)	<0.0123 (0.0062)	0.1035	<0.0245 (0.0145)	0.0335	<0.0008 (0.00054)	<0.2310 (0.1194)
AQ6	<0.0024 (0.0013)	<0.0123 (0.0062)	0.0799	<0.0245 (0.0130)	0.0245	<0.0008 (0.00067)	<0.2310 (0.1245)
AQ8	<0.0024 (0.0013)	<0.0123 (0.0062)	0.0702	<0.0245 (0.0132)	0.0269	<0.0008 (0.00055)	<0.2310 (0.1307)
FC1	<0.0024 (0.0015)	<0.0123 (0.0062)	0.0974	<0.0245 (0.0148)	0.0307	<0.0008 (0.00066)	<0.2310 (0.1201)
FC2	<0.0024 (0.0015)	<0.0123 (0.0062)	0.0936	<0.0245 (0.0149)	0.0281	<0.0008 (0.00059)	<0.2310 (0.1223)
FC3	<0.0024 (0.0012)	<0.0123 (0.0062)	0.0967	<0.0245 (0.0122)	0.0262	<0.0008 (0.00054)	<0.2310 (0.1227)
FC4	<0.0024 (0.0012)	<0.0123 (0.0062)	0.1037	<0.0245 (0.0122)	0.0270	<0.0008 (0.00044)	<0.2310 (0.1155)
FC5	<0.0024 (0.0015)	<0.0123 (0.0062)	0.1305	<0.0245 (0.0147)	0.0309	<0.0008 (0.00063)	<0.2310 (0.1155)
SQ1	<0.0024 (0.0014)	<0.0123 (0.0062)	0.0605	<0.0245 (0.0131)	0.0252	<0.0008 (0.00061)	<0.2310 (0.1174)
SQ2	<0.0024 (0.0015)	<0.0123 (0.0062)	0.0755	<0.0245 (0.0137)	0.0244	<0.0008 (0.00054)	<0.2310 (0.1169)

Note:
< #### indicates concentration was less than the lower certified reporting limit
(####) indicates computed average, when [Average] is less than the lower certified reporting limit.
μg/m³ Micrograms per cubic meter

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Table 4.4-4 Summary of FY93 24-Hour Maximum Metals, Arsenic, and Mercury Concentrations ($\mu g/m^3$)

Station	Cadmium	Chromium	Copper	Lead	Zinc	Arsenic	Mercury
AQ2	0.0089	<0.0123	0.2390	0.0692	0.1190	0.0018	0.3810
AQ3	0.0062	<0.0123	0.1400	0.0379	0.0853	0.0016	0.2940
AQ5	0.0077	<0.0123	0.1850	0.0614	0.1310	0.0018	0.3680
AQ6	0.0073	<0.0123	0.1710	0.0478	0.1000	0.0139	0.3940
AQ8	0.0074	<0.0123	0.1350	0.0507	0.1150	0.0035	0.6380
FC1	0.0088	<0.0123	0.2060	0.0524	0.1070	0.0033	0.2660
FC2	0.0091	<0.0123	0.2340	0.0496	0.0997	0.0023	0.3460
FC3	<0.0024	<0.0123	0.1610	<0.0245	0.0592	0.0012	0.2980
FC4	<0.0024	<0.0123	0.1860	<0.0245	0.0634	<0.0008	<0.2310
FC5	0.0092	<0.0123	0.2645	0.0546	0.1090	0.0021	<0.2310
SQ1	0.0095	<0.0123	0.3010	0.0497	0.1000	0.0081	0.2620
SQ2	0.0110	<0.0123	0.1320	0.0518	0.1010	0.0047	0.2220

Note: <#### indicates no values were detected above the lower certified reporting limit
$\mu g/m^3$ micrograms per cubic meter

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remedial activities. Maximum average and 24-hour concentrations measured in FY93 for each metal component are discussed below.

The highest average concentration of arsenic, 0.00067 $\mu g/m^3$, occurred just south of South Plants at AQ6 (this is below the certified detection level). The maximum 24-hour arsenic measurement was 0.0139 $\mu g/m^3$ at AQ6 on May 1, 1993. Arsenic was infrequently measured at RMA, but detections usually occurred at several or more stations at the same time. For example, on May 1, seven of eleven metal sampling sites measured arsenic at varying levels across RMA. A case study of this day is further reviewed in Section 4.4.4.2.

The maximum average cadmium value was only 0.0015 $\mu g/m^3$, measured at five of the ten stations that detected cadmium during FY93. This value is only slightly above half the detection limit; two stations did not detect any cadmium. The maximum 24-hour value was 0.0110 $\mu g/m^3$, measured at SQ1 on June 12, 1993, a high-event monitoring day (see Section 4.4.3.4 for further discussion of this episode).

During FY93, chromium was not detected at any monitoring site. Chromium was detected during FY92 on seven sampling days out of the possible 55 routine and high-event sample dates.

The highest annual average copper level for FY93, 0.1305 $\mu g/m^3$, occurred at FC4. The maximum 24-hour value for copper, 0.3010 $\mu g/m^3$, was measured at SQ1 during a high-event episode (see Section 4.4.3.11).

The highest FY93 average lead concentration was 0.0152 $\mu g/m^3$ (less than the detection limit of 0.0245 $\mu g/m^3$) at AQ2 at the northwestern perimeter, where the 24-hour maximum lead value was 0.0692 $\mu g/m^3$. These values were consistent with previous CMP measurements. The highest FY92 average lead value was 0.0156 $\mu g/m^3$ at AQ1, while the maximum lead concentration was 0.0443 $\mu g/m^3$ at AQ1.

The FY93 maximum average zinc concentration, 0.0434 $\mu g/m^3$, was measured at AQ2. The FY93 maximum 24-hour concentration of 0.1310 $\mu g/m^3$ was measured at AQ5. These values were very close to FY92 levels.

Mercury was detected on a number of individual sampling days during FY93, although on most days this element was below the detection limit. The highest average value was 0.1307 $\mu g/m^3$, which is slightly above half the detection limit. This was measured at AQ8. On July 15, 1993, a maximum mercury level of 1.6710 $\mu g/m^3$ was measured at AQ10, and a second maximum value of 0.7536 $\mu g/m^3$ was measured at a mobile site (M601N) during a metals high-event episode (see Section 4.4.3.7). Note that these were one-time measurements and were not included in summary Table 4.4-4. It is possible that these values are the result of laboratory contamination, as several problems with filter blanks were noted during this period.

4.4.3 High-Event Monitoring Case Studies

During FY93, high-event monitoring was conducted at a number of potential metal source areas as shown in Table 4.4-2. These episodes are reviewed in the following sections. Several cases of interest are illustrated in figures showing the distribution of metal concentrations at the high-event sampling sites.

4.4.3.1 January 22, 1993—Basin F

This was a winter day that readily met high-event criteria for metals. Winds averaged more than 12 mph for the 24-hour period and peak gusts exceeded 33 mph. Prevailing strong winds were from the south-southwest through south-southeast, with lighter winds from other directions. Figure 4.4-1 shows the distribution of metals concentrations at six sites, including two downwind Basin F sites, FC2 and FC4; also shown is the 24-hour wind rose for this day. There were no measurable concentrations of chromium, lead, arsenic and mercury at RMA on this date. There was one low measurement of cadmium (0.0028 $\mu g/m^3$); the highest zinc concentration was 0.0518 $\mu g/m^3$, both at AQ2. The highest copper concentration was 0.1180 $\mu g/m^3$ at FC4 suggesting that the remediated Basin F area may be a very weak source of copper. Basin F sites averaged

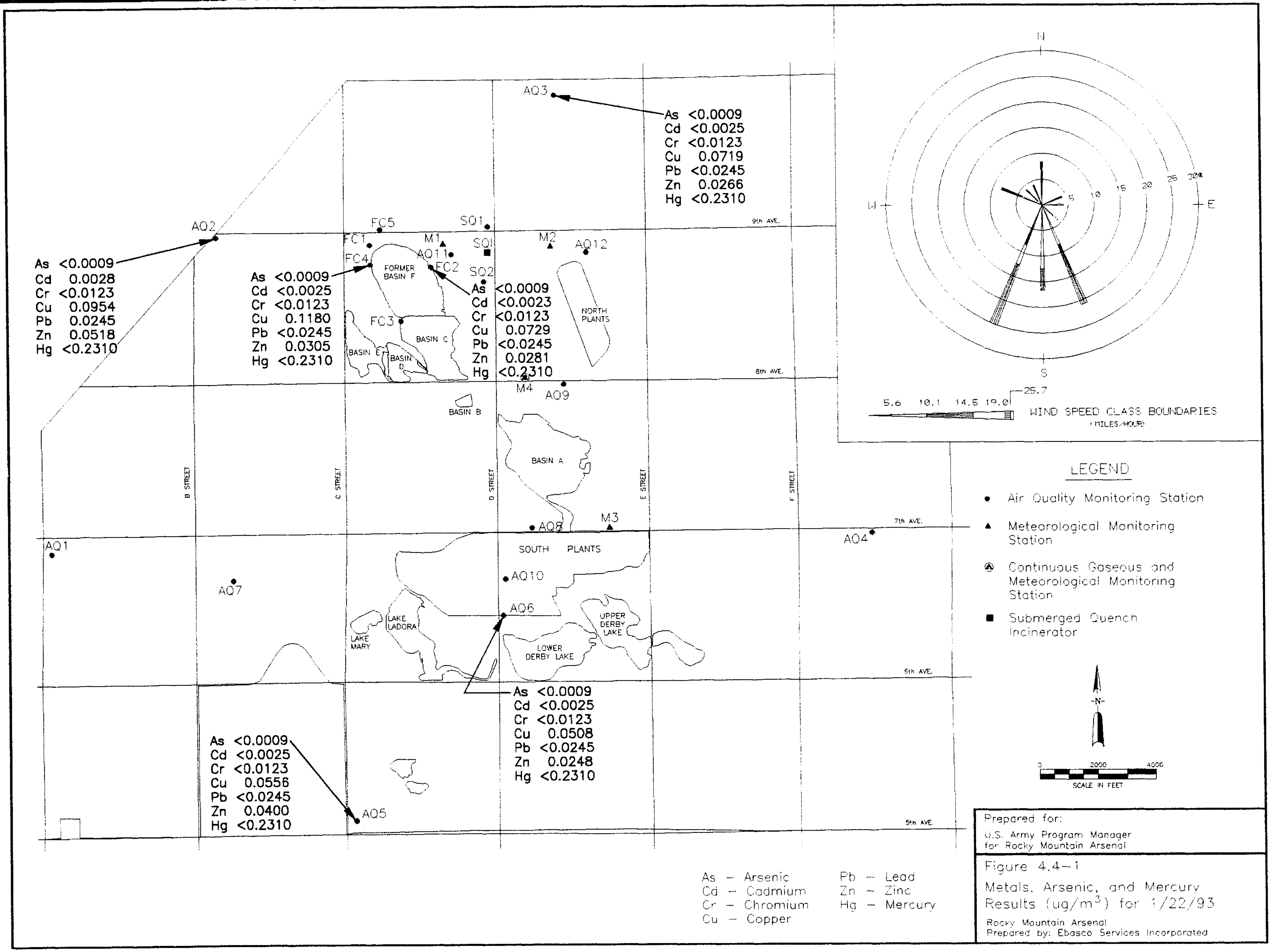

Figure 4.4–1

Metals, Arsenic, and Mercury Results (ug/m^3) for 1/22/93

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Prepared by: Ebasco Services Incorporated

slightly higher levels of copper as compared to the other RMA sites; however, AQ2 on the western boundary also showed levels comparable to the Basin F sites. In general, strong and gusty winds on this date indicated minimal metals impacts at the Basin F monitoring sites.

4.4.3.2 March 4, 1993—SQI

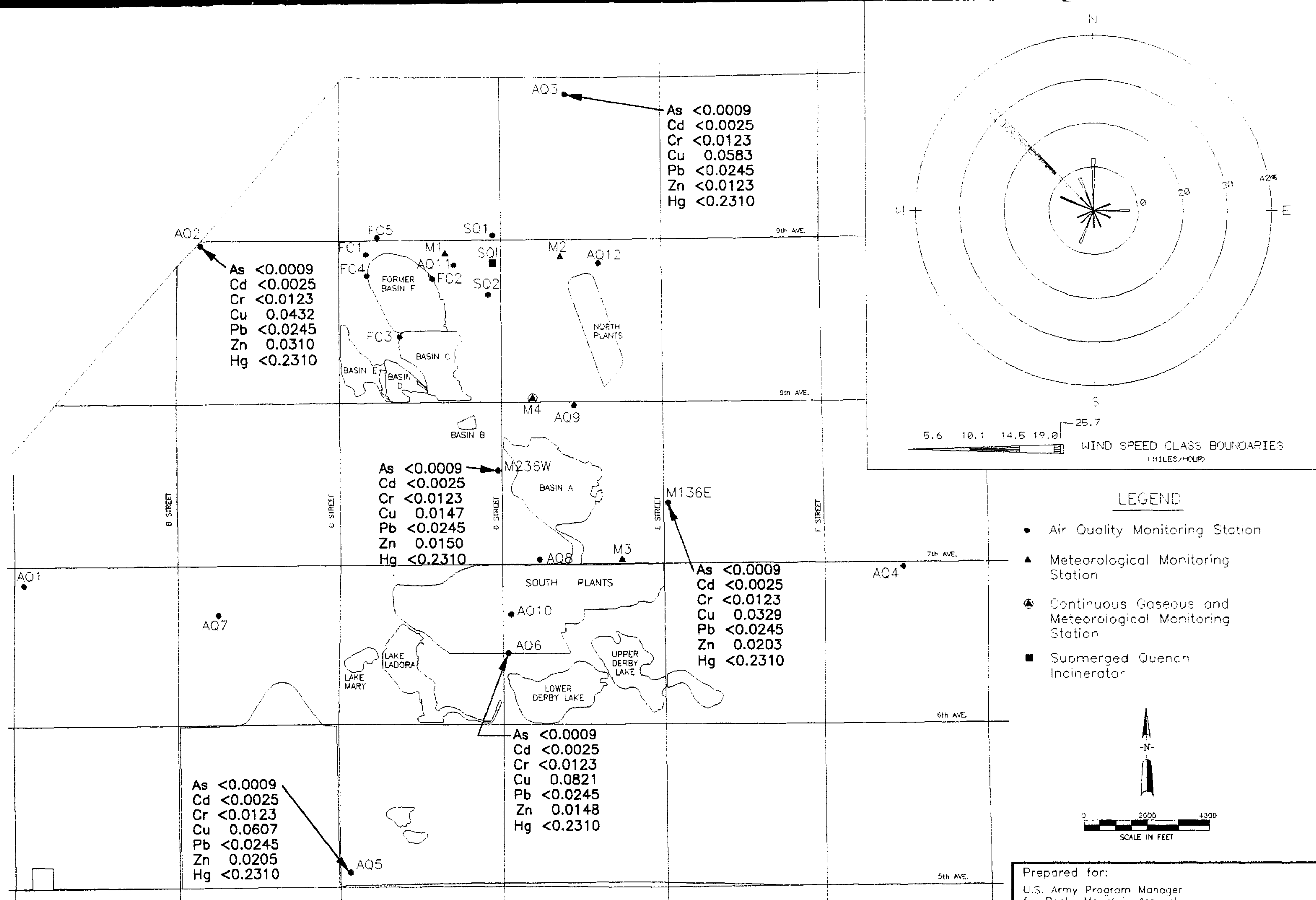
This was a late winter day with moderate winds, primarily from the northeast, and occasional gusts reaching more than 20 mph. Intense monitoring was conducted on this date for VOCs, SVOCS, and metals as a pre-SQI operational baseline evaluation. All metals concentrations at the SQI sites and at the mobile sites were well below normal levels except copper, which was 0.1120 $\mu g/m^3$ downwind at SQ2; this was comparable to average values of copper in the Basin F area. There did not appear to be a significant metal source in the SQI area on this date. A more complete review of SQI metals results is provided in Section 4.10.

4.4.3.3 April 10, 1993—Basin A

This was an excellent metals high-event monitoring day in early spring. Sustained winds frequently exceeded 20 mph and peak gusts reached 37 mph. Winds were primarily from the northwest. Monitoring was conducted south of Basin A at AQ6, east and west of the Basin at two mobile sites, and at perimeter sites. All metals levels were measured below the certified limit with exception of copper and zinc. Zinc was highest at AQ2, 0.0310 $\mu g/m^3$, suggesting off-post flow from the northwest, while copper was highest at AQ6, suggesting some influence off the old Basin floor. However, the level 0.0821 $\mu g/m^3$ was below typical RMA values. The data suggest that Basin A, which has been historically considered a potential source of metals, evidenced little or no metals impacts on this windy day. Figure 4.4-2 shows the measured metals concentrations at each RMA sampling site and wind rose for the 24-hour period of monitoring.

4.4.3.4 June 12, 1993—SQI

On this date, the metals impacts surrounding the SQI were again evaluated in conjunction with other parameters. At this time, however, the SQI was fully operational and undergoing special stack emissions tests. The winds were primarily from the south and gusts were moderate,



As – Arsenic
Cd – Cadmium
Cr – Chromium
Cu – Copper
Pb – Lead
Zn – Zinc
Hg – Mercury

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U.S. Army Program Manager for Rocky Mountain Arsenal

Figure 4.4–2
Metals, Arsenic and Mercury Results (ug/m^3) for 4/10/93

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occasionally reaching 30 mph. This was a typical late spring day with temperatures reaching 82°F. The highest levels of cadmium, copper, lead, and zinc were all measured at SQ2. However, with the winds blowing almost exclusively from the south (see Figure 4.4-3) and SQ1 levels consistently lower than SQ2, the implications are that the metals impacts did not come from SQI stack emissions; it is possible that Basin A or the South Plants complex to the south of SQ2 may have been a source of these emissions. It is also of interest that arsenic and mercury were sampled on this date at 12 monitoring sites. No arsenic was measured; however, one mercury measurement was sampled at AQ8 (just to the north of the South Plants). This level was 0.6380 $\mu g/m^3$ and was one of the higher mercury measurements during FY93.

4.4.3.5 June 24, 1993—Basin A

As a follow-up to the 12 June high-event episode, Basin A was intensely monitored on 24 June. Stations were located north, south, east, and west of the Basin. Winds were again from the south, and there were also strong east and north wind components. Average speeds were in excess of 11 mph and gusts reached 37 mph. The maximum temperature was 79° F. This time, there were no cadmium or mercury detections. Copper and zinc were highest along the southern RMA perimeter, and all metals levels were below detection in the Basin F area (see Figure 4.4-4). On this high-event day, Basin A did not appear to be a source of metals.

4.4.3.6 June 30, 1993—Basin F

This was an early summer day with temperatures above 90°F. Winds were moderate to strong with gusts reaching 30 mph. All metals concentrations were low or below the certified level with exception of mercury that was recorded at AQ2 at 0.247 $\mu g/m^3$. With mostly east and northeast winds on this date, a possible source of the mercury could have been the Basin F remediated area.

4.4.3.7 July 15, 1993—Basin A Soil Sifting

On this date, "soil sifting" activities of Basin A dirt were conducted in Building 545 in the South Plants. The area was surrounded with several permanent and mobile monitors, and sampling was

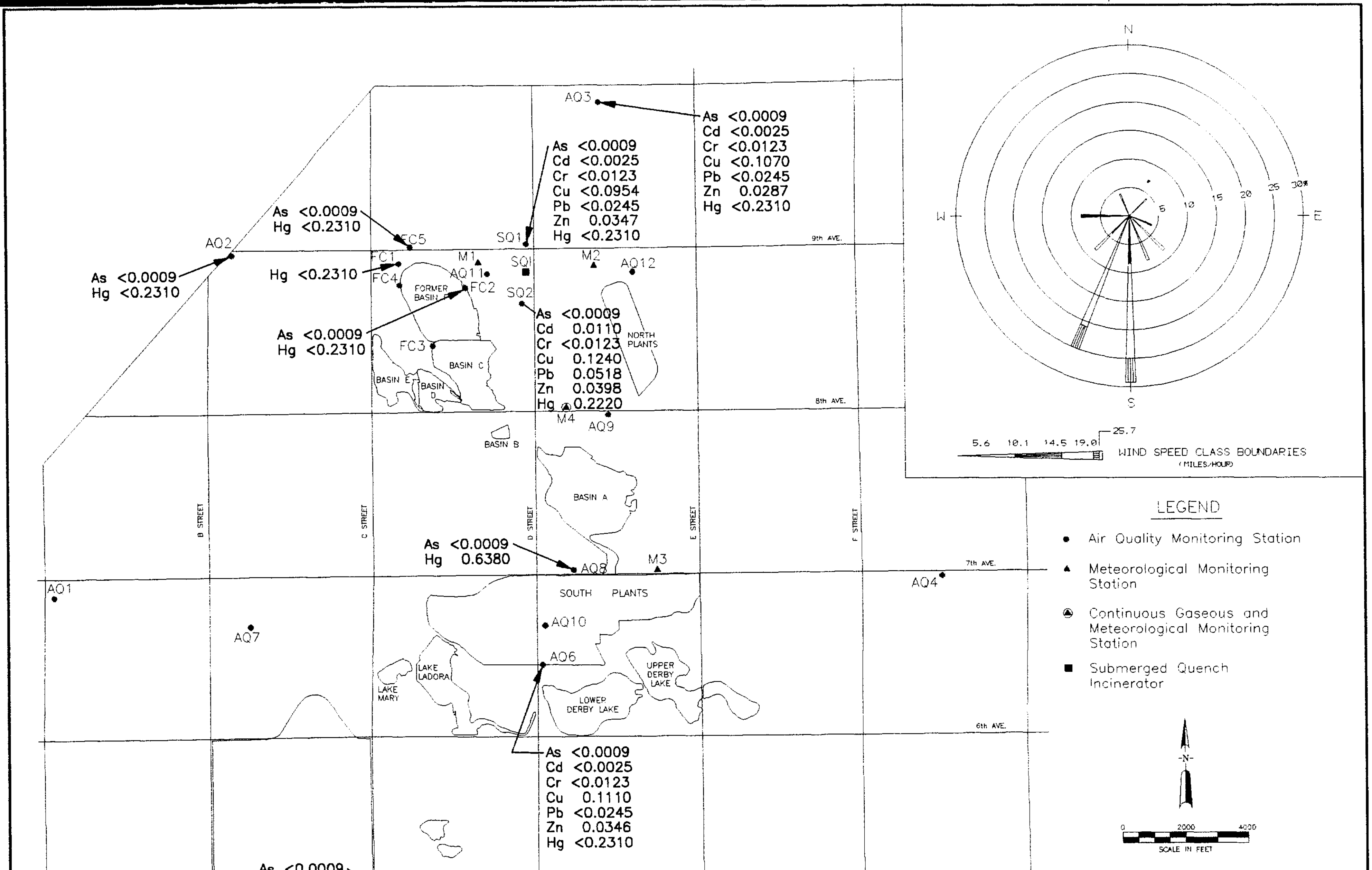

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Figure 4.4–3
Metals, Arsenic and Mercury
Results (ug/m³) for 6/12/93

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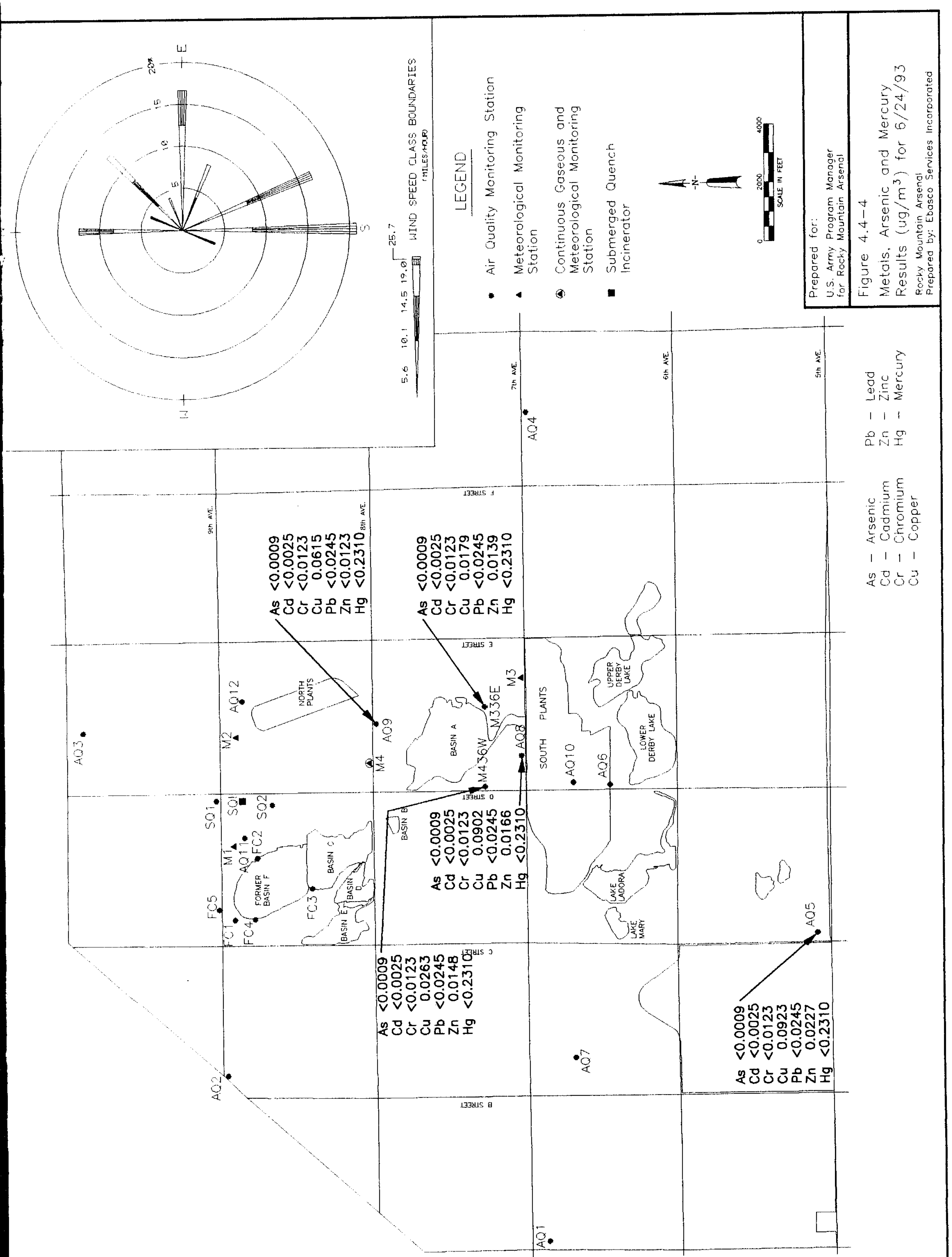

Figure 4.4-4
Metals, Arsenic and Mercury Results (ug/m^3) for 6/24/93

conducted for the 8 hours of operation. Most metals concentrations were low or below detection limits, although copper was slightly elevated, 0.1450 μg/m³ at the mobile M601N station.

On this metals high-event monitoring day, two high mercury readings were also recorded of 1.6710 μg/m³ at AQ10 and 0.7536 μg/m³ at mobile site M601N. It is possible that these values could be the result of laboratory contamination as several problems with filter blanks were noted during this period. The winds during the monitoring period were exclusively from the <u>northwest through northeast</u>. AQ10 was approximately 1,000 ft west-southwest of Building 545 and M601N was 100 feet east of the building. With respect to the soil sifting operations at Building 545, it would appear that mobile M701N, 100 feet to the south, would be more likely to experience impacts from the operation than AQ10 or M601N (see Figure 4.4-5). However, this sample site measured no detectable levels of mercury, as did none of the other sample sites. The contractor was not aware of any mercury in the sifted materials.

4.4.3.8 August 29, 1993—SQI

This was another SQI follow-on sampling assessment in conjunction with other parameters. Temperatures were in the low 80s and winds were primarily from the south quadrant at moderate speeds. All metals concentrations were below detection, with the exception of low copper and zinc levels (the only metals detected) at the RMA perimeter sites.

4.4.3.9 September 12, 1993—Basin F Waste Pile

This was a high event for mercury at the Basin F Waste pile. Winds were strong and persistent from the south-southwest. There were no mercury detections.

4.4.3.10 September 25, 1993—Brine Loading at Railroad Yard

Metals were sampled at the railroad yard complex on this early fall day. Winds were moderate from the south and south-southwest with lighter components from other directions; temperatures were in the 50s. Two mobile sites surrounded the activity. All concentrations were below the detection level or low; however, arsenic was detected at all of the RMA sites (see Figure 4.4-6).

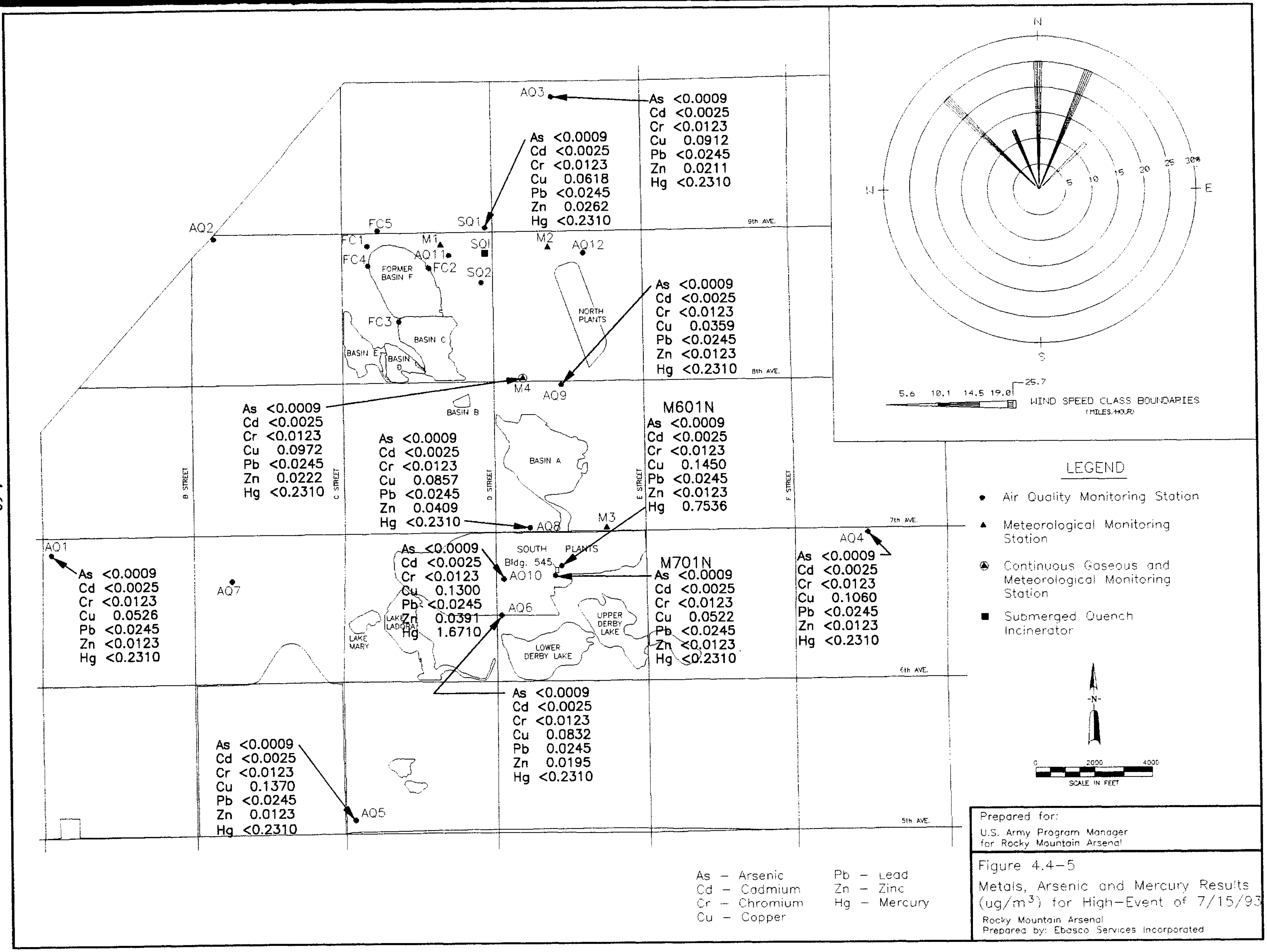

Figure 4.4–5

Metals, Arsenic and Mercury Results (ug/m^3) for High-Event of 7/15/93

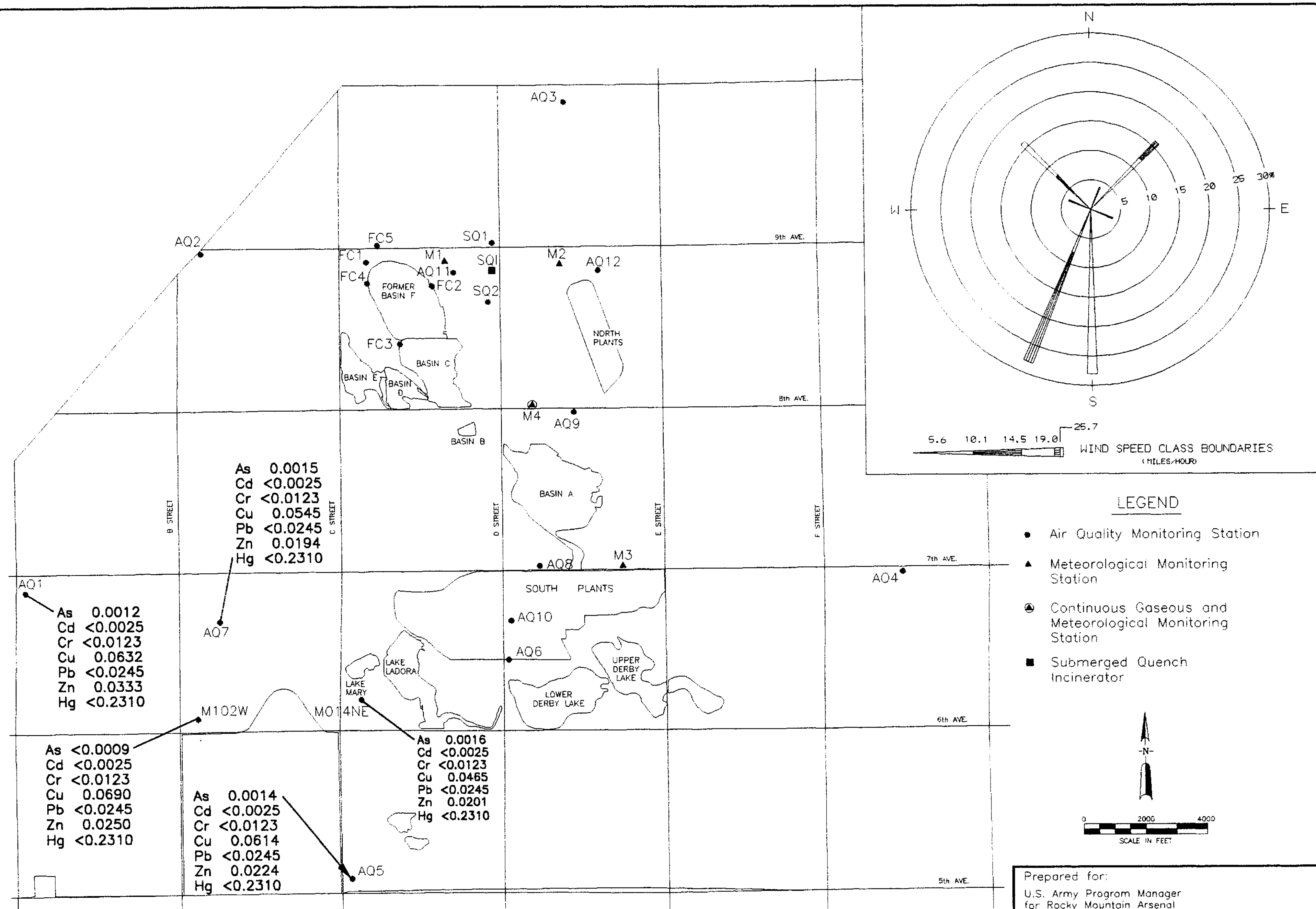

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Figure 4.4-6

Metals, Arsenic and Mercury Results (ug/m^3) for 9/25/93

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The arsenic levels were uniform at all six sampling sites including perimeter sites AQ1 and AQ5. With prevailing southerly winds, the arsenic source may have been off post.

4.4.3.11 September 28, 1993—Pond A Liner Cleaning

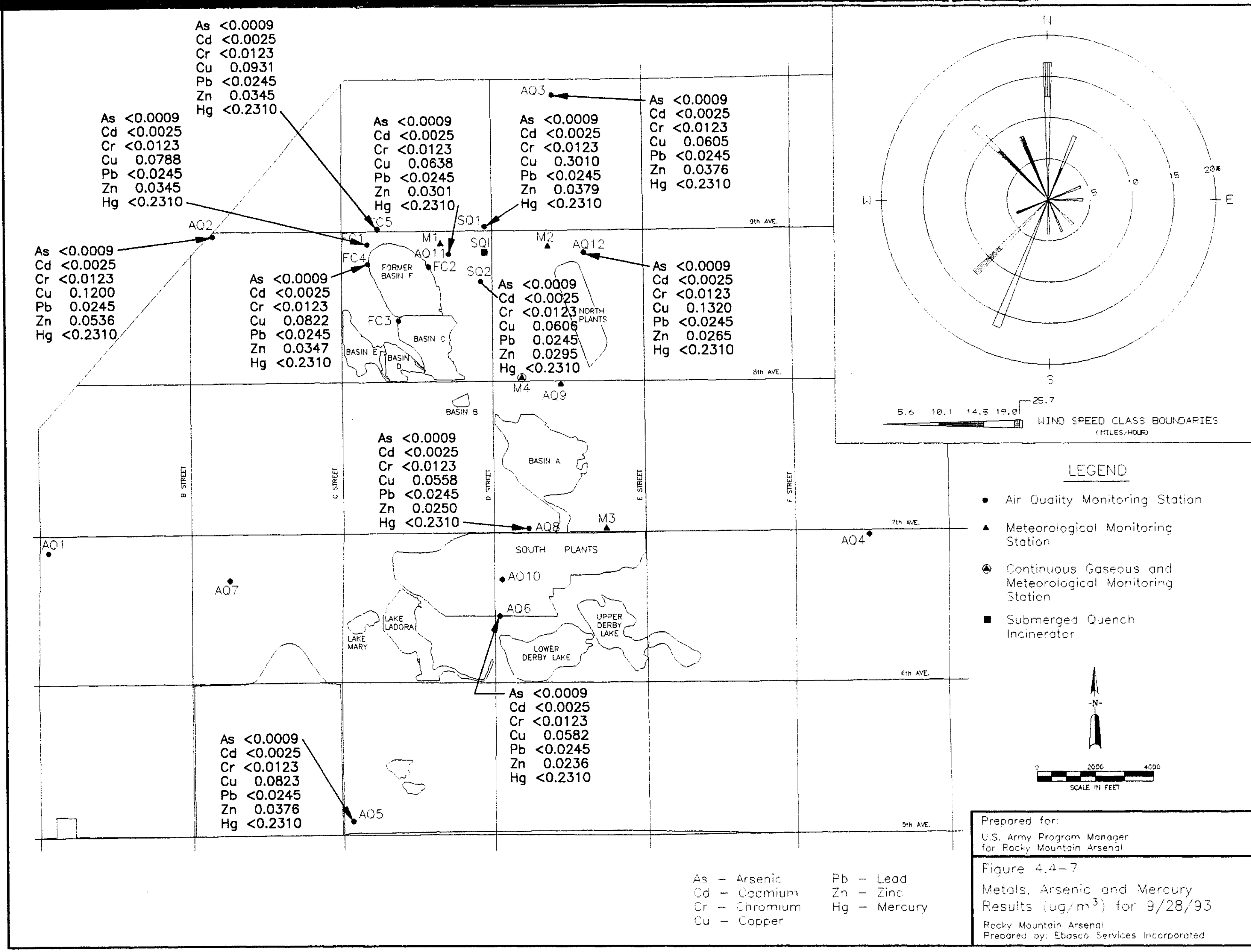
On this day, the liner over Pond A was cleaned, and metals and SVOC high-event monitoring was conducted. This was a mild fall day with variable winds at moderate speeds. Metals were monitored at 14 sites across RMA. All concentrations were low or below detection with exception of copper, which was measured at 0.3010 $\mu g/m^3$ at site SQ1. This was the highest 24-hour copper measurement during the FY93 program. A likely explanation is that "Cutrine-Plus", a copper compound (copper alkanlamine complex), was used in the liner cleaning process. The high copper level detection at SQ1 illustrates the sensitivity of the sampling process. Ambient metals concentrations on this day are shown in Figure 4.4-7.

4.4.3.12 September 30, 1993—Section 36 Excavations

On this date, metals were monitored during excavation activities in Section 36. Winds were primarily from the south-southwest with gusts near 30 mph. This met typical high-event meteorological criteria for metals; however, all concentrations were low or below detection with exception of zinc, which was slightly above average at all stations. The highest zinc level of 0.0742 $\mu g/m^3$ was at AQ1 with persistent south-southwest winds throughout the day, the implication is that the zinc source was from metropolitan Denver industrial activity.

4.4.3.13 High-Event Summary Discussion

It would appear that in FY93, gusty winds did not contribute to increased metals levels as in the past under more intense RMA remediation activities. On occasion, several downwind sampling sites showed slightly higher levels than upwind sites, but ambient levels remained within typical RMA ranges. The fact that high metals concentrations were not detected during these high-event conditions or during selected construction remediation activities remains meaningful for the CAQMMP. One of the key objectives of the program is to detect potential health hazards as



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U.S. Army Program Manager for Rocky Mountain Arsenal

Figure 4.4-7

Metals, Arsenic and Mercury Results (ug/m^3) for 9/28/93

Rocky Mountain Arsenal
Prepared by: Ebasco Services Incorporated

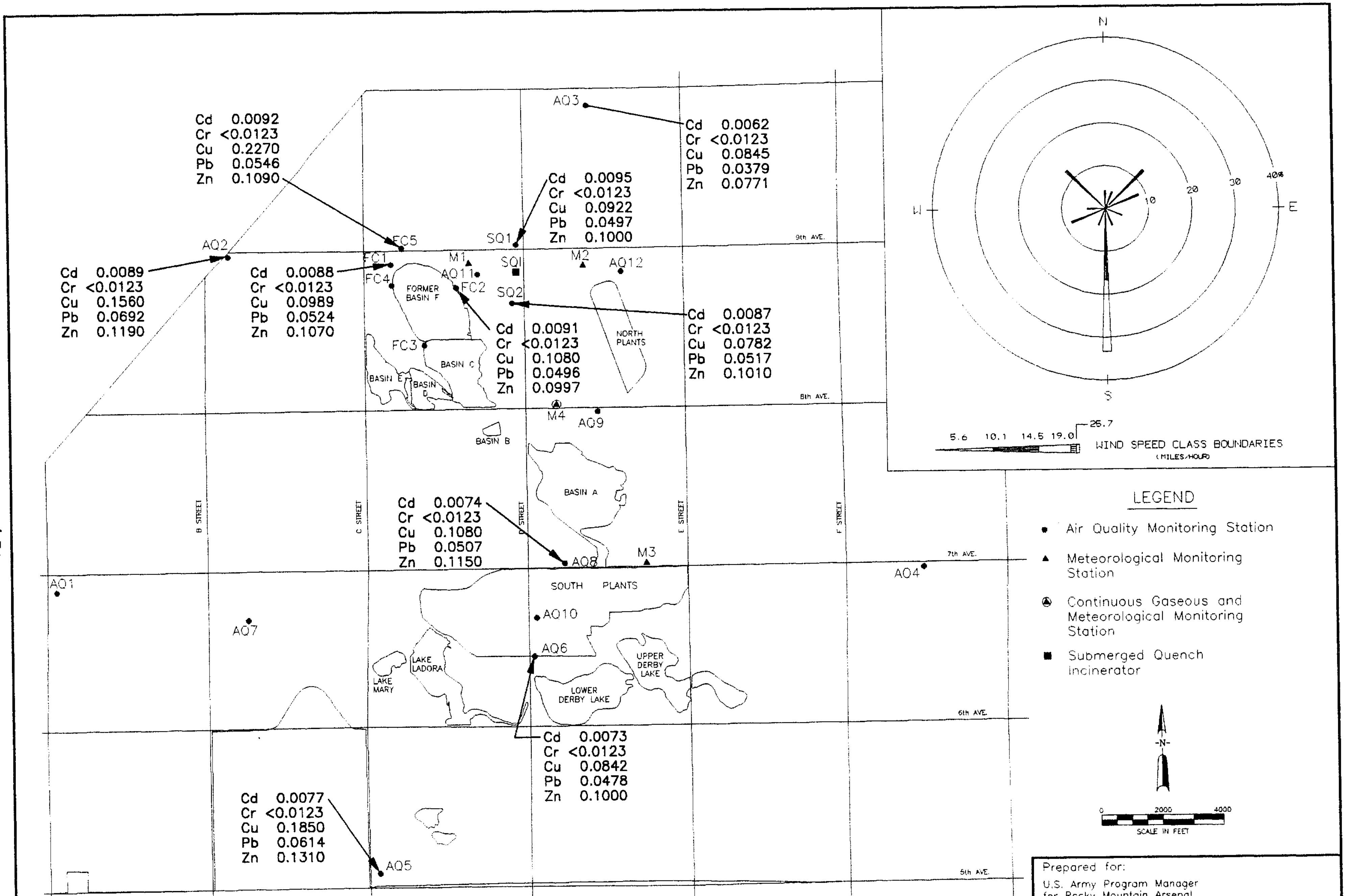


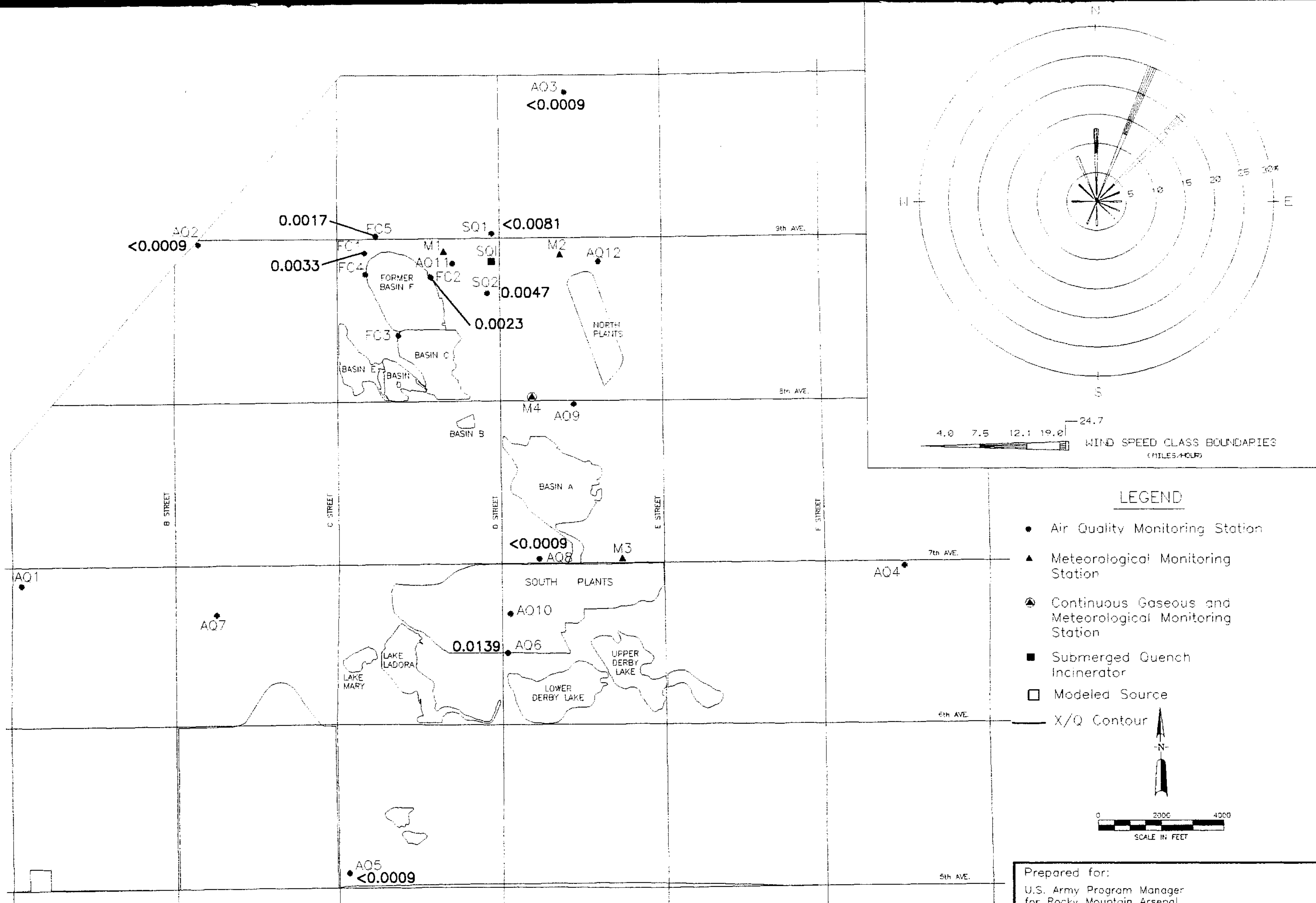
Figure 4.4-8
Metals Results (ug/m^3)for 12/8/92

Rocky Mountain Arsenal
Prepared by: Ebasco Services Incorporated

with other high wind days described above. A noted exception was arsenic, which was reported at seven of eleven metals sampling stations. Peak 24-hour arsenic concentrations of 0.0139 $\mu g/m^3$, 0.0081 $\mu g/m^3$, and 0.0047 $\mu g/m^3$ were measured at monitoring sites AQ6, SQ1, and SQ2, respectively. These were the three highest arsenic concentrations measured during FY93. Figure 4.4-9 indicates the distribution of arsenic across RMA on this date. The arsenic source is difficult to identify. Although the most frequent concentrations were clustered near Basin F and the SQI, the highest concentration was several miles to the south at AQ6; also there were no arsenic detections at AQ8, which is located to the north of AQ6. Several similar days with broad distributions of arsenic concentrations (at lower levels) were observed during FY93.

4.4.5 Assessment of Basin F Metals Impacts

During the Basin F cleanup program, air monitoring stations immediately adjacent to the intense remedial activity were able to identify several metals elements (chromium, copper, zinc, and mercury) that reflected higher concentrations. Those stations at the RMA perimeter or farther from Basin F measured typical semi-urban levels reflecting impacts from the Denver metropolitan area. In the post-remedial period, metals impacts from the Basin F area have been minimal. On occasion, they have been slightly above Arsenal interior concentrations but well below levels detected during the Phase 1 and Phase 2 remediation periods. This has been well documented in the previous CMP/CAQMMP annual assessment reports. The trend continued in FY93. For comparison purposes, Table 4.4-5 provides a listing of average and 24-hour maximum metals levels for the Phase 1 and Phase 2 (1988-1989 remediation periods) and the current Phase 7 (FY93) period. Note that several metals (cadmium, lead, and arsenic) did not appear to reflect special impacts from the Basin F remediation. Copper and zinc reflect comparable annual averages in both the remedial and post-remedial phases. Most striking is that the 24-hour maximum values for chromium, copper, zinc, and mercury show significant decreases after completion of remediation activities. It is interesting that arsenic, which has not been identified as a Basin F source metal, measured a 24-hour maximum peak level (for the CAQMMP history) in FY93.



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U.S. Army Program Manager
for Rocky Mountain Arsenal

Figure 4.4-9
Arsenic Results (ug/m^3) for 5/1/93

Rocky Mountain Arsenal
Prepared by: Ebasco Services Incorporated

Table 4.4-5 Summary of Average Metals and Mercury Results for Phases 1, 2-1, and 7 ($\mu g/m^3$)

Site	Phases	Cadmium	Chromium	Copper	Lead	Zinc	Arsenic	Mercury
BF1/FC1	Phase 1	0.0006	0.0128	0.1163	0.0148	0.0688	0.0008	1.6000
	Phase 2 Stage 1	0.0009	0.0036	0.0569	0.0200	0.2243	0.0008	1.3000
	Phase 7	0.0015	ND	0.0974	0.0148	0.0307	0.0007	0.1201
BF2/FC2	Phase 1	0.0008	0.0101	0.1516	0.0175	0.0727	0.0009	1.6000
	Phase 2 Stage 1	0.0006	0.0037	0.0646	0.0220	0.0931	0.0011	1.2000
	Phase 7	0.0015	ND	0.0936	0.0149	0.0281	0.0006	0.1223
BF3/FC3	Phase 1	0.0005	0.0176	0.0944	0.0138	0.0776	0.0007	1.5000
	Phase 2 Stage 1	0.0007	0.0026	0.0566	0.0181	0.1952	0.0009	1.2000
	Phase 7	ND	ND	0.0967	ND	0.0262	0.0005	0.1227
BF4/FC4	Phase 1	0.0006	0.0200	0.1258	0.0160	0.0779	0.0009	1.5000
	Phase 2 Stage 1	0.0007	0.0028	0.0578	0.0202	0.1494	0.0009	ND
	Phase 7	ND	ND	0.1037	0.1037	0.0270	ND	ND
BF5	Phase 1	0.0006	0.0026	0.0712	0.0144	0.0508	0.0012	1.2000
	Phase 2 Stage 1	0.0006	0.0031	0.0522	0.0159	0.3260	0.0008	ND
	Phase 7	*	*	*	*	*	*	*
FC5	Phase 1	*	*	*	*	*	*	*
	Phase 2 Stage 1	*	*	*	*	*	*	*
	Phase 7	0.0015	ND	0.1305	0.0147	0.0309	0.0006	ND

* Samples not collected at this site.
ND Not detected.
$\mu g/m^3$ Micrograms per cubic meter

Note: Phase 1 is from March 22 to December 12, 1988.
Phase 2, Stage 1 is from December 13, 1988 to February 15, 1989.
Phase 7 is from October 1, 1992 to September 30, 1993.

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Table 4.4-5 Summary of 24-Hour Maximum Metals and Mercury Results for Phases 1, 2-1, and 7 ($\mu g/m^3$)

Site	Phases	Cadmium	Chromium	Copper	Lead	Zinc	Arsenic	Mercury
BF1/FC1	Phase 1	0.0032	0.1520	0.3851	0.0258	0.5741	0.0025	4.7000
	Phase 2-1	0.0037	0.0149	0.0839	0.0499	0.9703	0.0024	1.5000
	Phase 7	0.0088	ND	0.2060	0.0524	0.1070	0.0033	0.2660
BF2/FC2	Phase 1	0.0149	0.1350	1.4980	0.0614	0.8106	0.0037	7.3000
	Phase 2-1	0.0016	0.0083	0.1226	0.0428	0.4959	0.0031	3.0000
	Phase 7	0.0091	ND	0.2340	0.0496	0.0997	0.0023	0.3460
BF3/FC3	Phase 1	0.0036	0.2083	0.5760	0.0292	0.5054	0.0018	7.3000
	Phase 2-1	0.0016	0.0037	0.0858	0.0430	0.9151	0.0032	2.1000
	Phase 7	ND	ND	0.1610	ND	0.0592	0.0012	0.2980
BF4/FC4	Phase 1	0.0037	0.2858	0.5349	0.0317	0.8651	0.0024	5.0000
	Phase 2-1	0.0016	0.0038	0.1004	0.0436	1.1316	0.0026	ND
	Phase 7	ND	ND	0.1860	ND	0.0634	ND	ND
BF5	Phase 1	0.0022	0.0087	0.1758	0.0434	0.2557	0.0136	2.1000
	Phase 2-1	0.0016	0.0075	0.0975	0.0260	3.3576	0.0028	ND
	Phase 7	*	*	*	*	*	*	*
FC5	Phase 1	*	*	*	*	*	*	*
	Phase 2-1	*	*	*	*	*	*	*
	Phase 7	0.0092	ND	0.2645	0.0546	0.1090	0.0021	ND

* Samples not collected at this site
ND Not detected
$\mu g/m^3$ Micrograms per cubic meter

Note: Phase 1 is from March 22 to December 12, 1988
Phase 2, Stage 1 is from December 13, 1988 to February 15, 1989
Phase 7 is from October 1, 1992 to September 30, 1993

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4.4.6 Analysis of Metals Source Factors

Detectable concentrations of metals sampled in the RMA vicinity appeared to result from a variety of sources. Observed concentrations of several metals may have originated from deposition in the soil around Basin F and occasionally from Basin A; other higher concentrations may have resulted from industrial and transportation activities in the Denver metropolitan area. Inherent in all the observed metals concentrations at RMA are baseline levels typical of the area's semi-urban environment. With the exception of these industry-related components, the metals were probably transported primarily by wind-blown dust and soil particles. In a CMP study conducted in FY89 (RLSA 1990a), the relationship was assessed between total metals (the sum of concentrations of all target metals compounds) collected under the Basin F program and TSP levels at Basin F during all remediation phases for Site BF2. Although there were typical variations in this database (the overall correlation factor was 0.68), the general inference was that the higher the TSP levels, the higher the levels of metals collected in the sample filters.

An analysis of average and maximum metals concentrations for FY93 indicated that, as in past years, high metals concentrations at RMA monitoring sites resulted from a number of sources and occurred under meteorological conditions conducive to high particulate concentrations. In the CMP FY88 Data Assessment Report, Table 4.2-16 showed in almost every case that the highest metal concentrations for each element at each monitoring site were associated with average 24-hour winds in excess of 10 mph and wind gusts in excess of 25 mph (RLSA 1990b). In contrast, the majority of high metals episodes subsequent to FY89 have resulted from "brown cloud" inversion impacts from metropolitan Denver (WCC 1993). Very high TSP and PM-10 concentrations at all RMA monitoring sites were also recorded on these dates, even though wind speeds were not very strong or gusty. Prevailing winds in all cases were from the south or southwest, indicating that impacts were from metropolitan Denver. The December 8, 1992 case study in Section 4.4.4.1 illustrates this situation.

4.4.7 Seasonal Metals Impacts

While some higher metals concentrations continued to be a function of strong and gusty winds, especially downwind from local construction and remediation activities, metals concentrations were generally higher during fall and winter inversion periods than under high wind scenarios. A study conducted for the CAQMMP FY92 Annual Report (WCC 1993) for a 5-year period for stations AQ3 and AQ5 indicated that the highest lead, zinc, and arsenic levels for both the average and 24-hour maximum values occurred in the fall or winter seasons. During spring when winds were frequently the strongest, lower concentrations were experienced for most metals except chromium, which was detected primarily during the spring and summer. In contrast, copper concentrations were reported at their highest during summer.

4.4.8 Assessment of Metals Concentrations

Table 4.4-6 summarizes the locations of maximum metals concentrations from both the CMP/CAQMMP and Basin F monitoring programs throughout the FY88-FY93 periods. The EPA and the State of Colorado have promulgated standards and published air toxic guidelines only for lead, for which a Colorado monthly standard of 1.5 $\mu g/m^3$ exists. During FY93, a maximum monthly average lead concentration of 0.0152 $\mu g/m^3$ was measured at perimeter site AQ2; this was 1 percent of the EPA criterion.

4.4.9 Summary

Ambient metals concentrations distributed across RMA were generally proportional to TSP concentrations. In the past, relatively high metals concentrations were generally associated with strong and gusty winds; however, exceptions to this trend were apparent in FY93 due to a number of different influences including the status of ongoing remediation and the effectiveness of post-remediation mitigation efforts such as reseeding and soil stabilization treatments. The extreme maxima were associated with poor dispersion conditions and light winds during winter and occurred on days with high particulate levels over Denver. Basin F appeared to be a potential source of chromium, mercury, copper, and zinc during Phase 1 remedial activities, but concentrations were localized and decreased rapidly with distance from the source. After

Table 4.4-6 Maximum Metals Concentrations at Rocky Mountain Arsenal ($\mu g/m^3$)

Metal	Maximum Long-term Average Concentration	Location	Phase	Maximum 24-Hour Concentration	Location	Phase
Arsenic	0.0025	AQ36	P4	0.0139	AQ6	P7
Cadmium	0.0027	FC2	P3	0.0281	AQ5	P4
Chromium	0.0200	BF4	P1	0.2858	BF4	P1
Copper	0.1825	AQ1	P6	1.4980	BF2	P1
Lead	0.0573	AQ7	P3	0.0984	AQ5	P2-S1
Zinc	0.3260	BF5	P2-S1	3.3576	BF5	P2-S1
Mercury	1.8000	BF2	P1	7.3000	BF2	P1

P1 is from March 22 to December 12, 1998.
P2-S1 is from December 13, 1988 to February 15, 1989.
P3 is from May 5 to September 30, 1989.
P4 is from October 1. 1989 to September 30, 1990 (FY90).
P6 is from October 1, 1989 to September 30, 1991 (FY92).
P7 is from October 1, 1992 to September 30, 1993 (FY93).

remediation, metals levels in the vicinity of Basin F were typical of RMA baseline concentrations. None of the metals concentrations measured during the CAQMMP high-event days in FY93 indicated significant toxic or contamination levels.

4.5 ASBESTOS

Asbestos sampling was conducted at four sites on a monthly basis during FY93. Stations were selected based upon their proximity to potential sources of asbestos. Table 4.5-1 lists sample locations and data recovery rates.

In January of FY93, the target sample flowrate was lowered from 7 standard liters per minute (slpm) to 1.4 slpm due to the collection of excessive levels of particulate and other background material on the sample filter. Samples with fiber counts above 1,300 fibers per square millimeter (fmm^{-2}) and fiber counts from samples with greater than 50 percent of the filter area covered with particulates were reported as "cannot be read" (CBR). The reduction in flowrate appeared to have corrected this problem.

The estimated level of detection for this method is 7 fmm^{-2} (this corresponds to a concentration of 0.001 fibers per milliliter). All samples collected in FY93 had fiber counts below this minimum detection level. (Refer to Appendix D for complete listing of asbestos results). In summary, asbestos detections were minimal in FY88, FY89, FY90, and FY91 with no detections in FY92 and FY93. The concentration of asbestos in RMA ambient air is generally quite low.

4.6 VOLATILE ORGANIC COMPOUNDS

4.6.1 CAQMMP VOC Sampling, Analysis, and Reporting Strategies.

The CAQMMP Technical Plan calls for routine 6-day, monthly, and seasonal monitoring of VOCs; special weekly and monthly VOC monitoring at the air stripper; quarterly monitoring at the waste pile, Pond A, and tank vents; and an extensive VOC high-event monitoring program

Table 4.5-1 Synopsis of FY93 Asbestos Monitoring

Station	Samples Scheduled	Samples Collected	Percent Recovery
AQ1	12	12	100
AQ6	12	12	100
AQ8	12	12	100
AQ12	12	12	100
Duplicate	12	12	100
Field Blank	12	12	100
Trip Blank	12	12	100
Total	84	84	100

(discussed in Section 4.6.4). Details of the monitoring program have been previously provided in Section 3 and in Table 3.2-2. Table 4.6-1 provides a summary of the routine FY93 VOC program including the schedule and the recovery data at each of the sampling sites.

In FY91, the VOC sampling frequency was increased to every sixth day at 10 stations, and monthly and seasonally at five additional stations (including collocated stations). This sampling strategy has continued through FY93. As indicated in previous reports, low VOC certification ranges have, on occasion, resulted in values above the certification range. As a result, the laboratory has estimated VOC target analyte levels that were above the CRL using standard laboratory analytical methods of retrieval. The fact that certain target analytes were measured and analyzed above certification levels is a reflection of the limitations of the certification ranges and does not necessarily imply that these levels represented potential contamination risks. The available data, in fact, reflect the contrary. The data listing of VOCs collected in FY93 are provided in Appendix E. It is noted that those measurements listed as "greater than" (GT) do not meet IRDMIS certification criteria. In this section, however, all of the sample results are summarized and evaluated and the data above certified reporting limits have been incorporated into the analyses.

During FY93, VOC sampling included not only routine and high-event sampling, but real-time and integrated air sampling at Basin A vent sites, Pond A, and three storage tanks sites. In addition, VOC monitoring was conducted at the Basin A air stripper facility. These results are provided in Sections 4.8 and 4.9.

Two additional programs were conducted in FY93 involving VOCs. First, an SQI air quality support program was conducted in which VOC monitoring was a principal ingredient. Results of this investigation are provided in Section 4.10. Second, operational testing and air monitoring of the SVE system in the RMA motor pool area was performed from September 29 to October 1, 1993. Results of these tests are provided in Section 4.11.

Table 4.6-1 Summary of Volatile Organic Compound Monitoring for FY93

Station	Samples Scheduled	Samples Collected	Valid Samples	Field % Recovery	Overall % Recovery
AQ1	4	5	5	125*	125*
AQ2	61	55	52	90	85
AQ3	61	53	50	87	82
AQ4	4	3	3	75	75
AQ5	61	56	52	92	85
AQ6	61	53	51	87	84
FC1	61	55	53	90	87
FC2	61	53	50	87	82
FC3	12	12	12	100	100
FC4	12	12	10	100	83
FC5	61	55	53	90	87
SQ1	61	53	52	87	85
SQ2	61	53	50	87	82
Duplicate	61	60	54	98	89
Overall	642	578	547	90	85

* Values over 100% reflect more samples taken than scheduled

% percent

During FY93, the problems with the CMO4 VOC method of field sampling using Tenax and Tenax/charcoal tubes and certification limitations have continued to be concerns for the CAQMMP. In recent years VOC sample flow rates and tube train configurations have been investigated and modified (WCC 1993). Nevertheless, two major concerns remained: (1) measurements above certification limits, as discussed above; and (2) breakthroughs of the more volatile organic compounds. These investigations were continued in FY93 and summarized in reports to PMRMA. In addition, alternative methods of VOC sampling, including, in particular, the use of passivated canisters, were investigated. During August and September of 1993, PMRMA authorized the testing of canisters in conjunction with Tenax/charcoal tubes at collocated sites. These results are currently being evaluated and it is anticipated that a concerted effort will be forthcoming to incorporate canisters into the VOC monitoring program. Discussions relating to VOC investigations and the canister tests are provided in Sections 4.6.8 and 4.6.9.

4.6.2 CAQMMP FY93 VOC Monitoring Results

VOCs were monitored in FY93 routinely and for high-event conditions. Tables 4.6-2 and 4.6-3 present summaries of results of the sampling of target VOC analytes at both fixed and mobile locations, including all high-event results. Table 4.6-2 shows the annual average and Table 4.6-3 shows the 24-hour maximum concentrations of each VOC at each site. For averaging purposes, those VOCs below the CRL were assigned a value of one-half of the detection limit (averages below the CRLs are shown in parentheses in Table 4.6-2).

Measured VOCs during FY93 were comparable to concentrations observed during previous years. However, several of the average and 24-hour maximum levels were higher than the previous year's results because estimates of concentrations above the certified limits were not reported during the FY92 period. This procedure was followed in all previous CMP assessments (FY88 through FY91) and was reestablished in order to maintain continuity of the program and also as to evaluate remedial progress. One additional explanation for higher 24-hour maximum VOC values in FY93 was the result of a single day's sampling measurements. As noted elsewhere in

Table 4.6-2 Summary of FY93 Average Volatile Organic Compound Concentrations ($\mu g/m^3$)

	111TCE	112TCE	11DCLE	12DCLE	12DCE	BCHPD	C6H6	CCL4	CH2CL2	CHCL3
AQ1	1.785	<0.167 (0.084)	<0.056 (0.028)	<0.056 (0.036)	<0.056 (0.028)	<0.056 (0.028)	2.779	0.593	113.432	0.203
AQ2	1.954	<0.167 (0.084)	<0.056 (0.028)	<0.056 (0.039)	<0.056 (0.028)	<0.056 (0.028)	3.178	0.758	14.178	0.585
AQ3	1.508	<0.167 (0.084)	<0.056 (0.028)	<0.056 (0.039)	<0.056 (0.028)	<0.056 (0.030)	2.019	0.718	16.712	0.336
AQ4	1.182	<0.167 (0.084)	<0.056 (0.028)	<0.056 (0.040)	<0.056 (0.028)	<0.056 (0.028)	1.192	0.588	32.652	0.097
AQ5	2.670	<0.167 (0.084)	<0.056 (0.028)	<0.056 (0.030)	<0.056 (0.028)	<0.056 (0.029)	2.817	0.646	8.387	0.264
AQ6	1.771	<0.167 (0.084)	<0.056 (0.028)	<0.056 (0.037)	<0.056 (0.028)	<0.056 (0.028)	2.070	0.656	18.036	0.304
FC1	1.945	<0.167 (0.084)	<0.056 (0.028)	<0.056 (0.032)	<0.056 (0.028)	<0.056 (0.040)	3.304	0.781	8.484	1.115
FC2	1.892	<0.167 (0.084)	<0.056 (0.028)	<0.056 (0.040)	<0.056 (0.028)	0.085	2.651	0.743	7.667	1.755
FC3	1.778	<0.167 (0.084)	<0.056 (0.028)	<0.056 (0.039)	<0.056 (0.028)	<0.056 (0.031)	2.992	0.576	2.263	0.716
FC4	2.200	<0.167 (0.084)	<0.056 (0.028)	<0.056 (0.047)	<0.056 (0.028)	<0.056 (0.028)	3.339	0.748	2.355	0.556
FC5	1.777	<0.167 (0.084)	<0.056 (0.028)	<0.056 (0.033)	<0.056 (0.028)	<0.056 (0.038)	2.522	0.738	8.358	0.997
SQ1	1.690	<0.167 (0.084)	<0.056 (0.028)	<0.056 (0.031)	<0.056 (0.028)	<0.056 (0.028)	2.361	0.717	16.821	0.589
SQ2	1.686	<0.167 (0.084)	<0.056 (0.028)	<0.056 (0.030)	<0.056 (0.030)	<0.056 (0.028)	2.178	0.716	13.586	0.565

$\mu g/m^3$ - micrograms per cubic meter
< #### indicates concentration is less than lower certified reporting limit.
(####) indicates computed average when [average] is less than lower certified reporting limit.

111TCE - 1,1,1-Trichloroethane
112TCE - 1,1,2-Trichloroethane
11DCLE - 1,1-Dichloroethane
12DCLE - 1,2-Dichloroethane
12DCE - trans-1,2-Dichloroethene
BCHPD - Bicycloheptadiene
C6H6 - Benzene
CCL4 - Carbon Tetrachloride
CH2CL2 - Methylene Chloride
CHCL3 - Chloroform

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Table 4.6-2 Summary of FY93 Average Volatile Organic Compound Concentrations ($\mu g/m^3$)

	CLC6H5	DBCP	DCPD	DMDS	ETC6H5	MEC6H5	MIBK	TCLEE	TRCLE	XYLENES
AQ1	<0.060 (0.030)	<0.462 (0.231)	<0.412 (0.206)	<0.218 (0.114)	0.698	5.278	<0.741 (0.370)	0.576	<0.060 (0.040)	3.319
AQ2	<0.060 (0.030)	<0.462 (0.231)	<0.412 (0.206)	<0.218 (0.114)	0.774	5.980	<0.741 (0.370)	0.645	<0.060 (0.043)	3.712
AQ3	<0.060 (0.031)	<0.462 (0.231)	<0.412 (0.206)	<0.218 (0.114)	0.506	3.956	<0.741 (0.370)	0.394	<0.060 (0.038)	2.372
AQ4	<0.060 (0.030)	<0.462 (0.231)	<0.412 (0.206)	<0.218 (0.114)	0.301	3.009	<0.741 (0.370)	0.424	<0.060 (0.030)	1.453
AQ5	<0.060 (0.030)	<0.462 (0.231)	<0.412 (0.206)	<0.218 (0.114)	0.779	6.085	<0.741 (0.370)	0.782	<0.060 (0.045)	3.745
AQ6	<0.060 (0.030)	<0.462 (0.231)	<0.412 (0.206)	<0.218 (0.114)	0.487	4.020	<0.741 (0.370)	0.436	<0.060 (0.035)	2.334
FC1	<0.060 (0.030)	<0.462 (0.231)	<0.412 (0.206)	<0.218 (0.114)	0.687	5.149	<0.741 (0.370)	0.632	<0.060 (0.047)	3.306
FC2	<0.060 (0.030)	<0.462 (0.231)	<0.412 (0.206)	<0.218 (0.114)	0.639	4.776	<0.741 (0.370)	0.640	<0.060 (0.044)	3.087
FC3	<0.060 (0.030)	<0.462 (0.231)	<0.412 (0.206)	<0.218 (0.114)	0.924	6.383	<0.741 (0.370)	0.704	0.068	4.701
FC4	<0.060 (0.030)	<0.462 (0.231)	<0.412 (0.206)	<0.218 (0.114)	0.857	6.068	<0.741 (0.370)	0.769	0.063	4.256
FC5	<0.060 (0.030)	<0.462 (0.231)	<0.412 (0.206)	<0.218 (0.114)	0.611	4.578	<0.741 (0.370)	0.550	<0.060 (0.042)	2.914
SQ1	<0.060 (0.030)	<0.462 (0.231)	<0.412 (0.206)	<0.218 (0.114)	0.656	4.775	<0.741 (0.370)	0.612	<0.060 (0.048)	2.979
SQ2	<0.060 (0.030)	<0.462 (0.231)	<0.412 (0.206)	<0.218 (0.114)	0.517	3.960	<0.741 (0.370)	0.464	<0.060 (0.037)	2.388

$\mu g/m^3$ - micrograms per cubic meter
< #### indicates concentration is less than the lower certified reporting limit
(####) indicates computed average when [average] is less than the lower certified reporting limit

CLC6H5 -	Chlorobenzene	MEC6H5 -	Toluene
DBCP -	Dibromochloropropane	MIBK -	Methyl isobutyl ketone
DCPD -	Dicyclopentadiene	TCLEE -	Tetrachloroethene
DMDS -	Dimethyl disulfide	TRCLE -	Trichloroethene
ETC6H5 -	Ethyl benzene	XYLENES -	Total xylenes

RMA/0975 10/19/94 2:58 pm bpw

Table 4.6-3 Summary of FY93 24-Hour Maximum Volatile Organic Compound Concentrations (μg/m³)

	111TCE	112TCE	11DCLE	12DCLE	12DCE	BCHPD	C6H6	CCL4	CH2CL2	CHCL3
AQ1	3.934	<0.167	<0.056	0.069	<0.056	<0.056	6.404	0.932	560.000	0.547
AQ2	7.373	<0.167	<0.056	0.300	<0.056	<0.056	11.982	5.400	390.295	13.570
AQ3	4.854	<0.167	<0.056	0.301	0.100	0.148	9.800	1.500	395.000	2.433
AQ4	1.400	<0.167	<0.056	0.063	<0.056	<0.056	2.380	1.000	97.000	0.199
AQ5	20.093	<0.167	<0.056	0.086	<0.056	0.104	11.682	1.136	295.455	2.889
AQ6	6.161	<0.167	<0.056	0.130	<0.056	<0.056	9.548	1.380	440.870	1.898
FC1	6.160	<0.167	<0.056	0.074	<0.056	0.205	31.430	2.100	293.023	5.070
FC2	6.512	<0.167	<0.056	0.250	<0.056	0.626	13.488	1.470	184.700	4.870
FC3	2.830	<0.167	<0.056	0.155	<0.056	0.061	7.143	0.823	11.556	1.790
FC4	3.930	<0.167	<0.056	0.180	<0.056	<0.056	8.559	1.150	10.455	1.200
FC5	5.090	<0.167	<0.056	0.140	<0.056	0.168	9.211	2.350	273.300	2.910
SQ1	13.130	<0.167	<0.056	0.078	<0.056	<0.056	33.830	2.050	305.000	6.110
SQ2	5.652	<0.167	<0.056	0.094	0.200	<0.056	11.304	2.100	254.579	3.650

μg/m³ micrograms per cubic meter
< #### indicates the concentration is less than the lower certified reporting limit

111TCE - 1,1,1-Trichloroethane
112TCE - 1,1,2-Trichloroethane
11DCLE - 1,1-Dichloroethane
12DCLE - 1,2-Dichloroethane
12DCE - trans-1,2-Dichloroethene
BCHPD - Bicycloheptadiene
C6H6 - Benzene
CCL4 - Carbon Tetrachloride
CH2CL2 - Methylene Chloride
CHCL3 - Chloroform

RMA/0976 10/19/94 3:00 pm bpw

Table 4.6-3 Summary of FY93 24-Hour Maximum Volatile Organic Compound Concentrations (μg/m³)

	CLC6H5	DBCP	DCPD	DMDS	ETC6H5	MEC6H5	MIBK	TCLEE	TRCLE	XYLENES
AQ1	<0.060	<0.462	<0.412	<0.218	2.010	13.340	<0.741	1.630	0.078	9.310
AQ2	<0.060	<0.462	<0.412	<0.218	4.480	29.032	<0.741	4.590	0.380	22.120
AQ3	<0.068	<0.462	<0.412	<0.218	5.000	30.000	<0.741	2.700	0.227	23.000
AQ4	<0.060	<0.462	<0.412	<0.218	0.754	6.667	<0.741	0.913	0.060	3.670
AQ5	<0.060	<0.462	<0.412	<0.218	4.720	51.402	<0.741	7.477	0.303	22.430
AQ6	<0.060	<0.462	<0.412	<0.218	2.190	26.066	<0.741	3.610	0.122	10.200
FC1	<0.060	<0.462	<0.412	<0.218	4.060	32.093	<0.741	5.630	0.250	18.605
FC2	<0.060	<0.462	<0.412	<0.218	3.740	24.186	<0.741	5.020	0.202	19.535
FC3	<0.060	<0.462	<0.412	<0.218	2.150	13.839	<0.741	1.390	0.115	11.700
FC4	<0.060	<0.462	<0.412	<0.218	2.320	17.568	<0.741	2.260	0.141	13.000
FC5	<0.060	<0.462	<0.412	<0.218	4.350	23.830	<0.741	3.300	0.178	20.560
SQ1	<0.060	<0.462	<0.412	<0.218	14.120	87.560	<0.741	16.780	0.657	51.390
SQ2	<0.060	<0.462	<0.412	<0.218	4.230	29.800	<0.741	3.370	0.180	19.810

μg/m³ micrograms per cubic meter
< #### indicates the concentration is less than the lower certified reporting limit

CLC6H5 - Chlorobenzene
DBCP - Dibromochloropropane
DCPD - Dicyclopentadiene
DMDS - Dimethyl disulfide
ETC6H5 - Ethyl benzene
MEC6H5 - Toluene
MIBK - Methyl isobutyl ketone
TCLEE - Tetrachloroethene
TRCLE - Trichloroethene
XYLENES - Total xylenes

RMA/0976 10/19/94 3:00 pm ap

this report, December 8, 1992 was a particularly bad air quality day in metropolitan Denver. Levels of suspended particulates, metals, and criteria gaseous pollutants reached their highest levels of the year, both in downtown Denver and at RMA. With respect to VOCs, seven analytes, 1,1,1-trichloroethane, benzene, toluene, ethylbenzene, trichloroethene, tetrachloroethene, and xylene, measured their highest 24-hour concentrations for the year on this date. Many concentrations were close to FY88 (Phase 1) Basin F levels, and two VOCs, ethylbenzene and xylene, exceeded the peak Basin F remedial period 24-hour measurements. The December 8, 1992 case study will be reported in further detail in Section 4.6.5.1.

Another VOC that reached its highest average and 24-hour levels during FY93 was methylene chloride. This compound was detected at high levels at a number RMA monitoring sites between April 16 and June 13, 1993. No specific location or activity at RMA has been identified as a potential source of the methylene chloride emissions. Potential on- and off-post sources have been investigated (and these investigations continue). See Section 4.6.5.2 for a more detailed discussion of the methylene chloride results.

Table 4.6-4 provides a listing of where long-term (annual) average and maximum 24-hour concentrations of individual VOC analytes were located in FY93. Although many of the highest average concentrations were measured at Basin F sites, average concentrations were, for the most part, uniformly distributed across RMA during FY93 (as shown in the composite results, Table 4.6-2). Those analytes previously identified as potential emissions from Basin F (benzene, bicycloheptadiene, chloroform, ethylbenzene, toluene, and dimethyldisulfide) were well below Basin F remediation levels and only slightly higher at Basin F than at other RMA sampling locations. 1,1,1-trichloroethane and tetrachloroethene were highest at the south perimeter (Station AQ5).

Many of the 24-hour maximum values occurred at RMA perimeter sites. However, six analytes (benzene, ethylbenzene, toluene, tetrachloroethene, trichloroethene, and total xylenes) were measured at the highest 24-hour maximum levels at SQ1. It is important to note that these

Table 4.6-4 Maximum Volatile Organic Compound Concentrations at Rocky Mountain Arsenal During CAQMMP, CMP, Basin F, and IRA-F Programs (μg/m^3)

Analyte	Maximum 24-Hour Concentration	Location	Date	Maximum Annual Avg. Conc.	Location
1,1,1-Trichloroethane	20.093	AQ5	12/08/92	2.670	AQ5
1,1,2-Trichloroethane	< 0.170	NA	NA	< 0.170	NA
1,1-Dichloroethane	< 0.056	NA	NA	< 0.056	NA
1,2-Dichloroethane	0.301	AQ3	01/07/93	< 0.056	NA
Trans-1,2-Dichloroethene	0.200	SQ2	06/15/93	< 0.056	NA
Bicycloheptadiene	1.440	FC2D	08/29/93	0.085	FC2
Benzene	33.830	SQ1	12/08/92	3.339	FC4
Carbon Tetrachloride	5.400	AQ2	09/04/93	0.781	FC1
Methylene Chloride	560.000	AQ1	06/03/93	18.036*	AQ6*
Chloroform	13.570	AQ2	09/04/93	1.755	FC2
Chlorobenzene	0.068	AQ3	02/24/93	< 0.060	NA
Dibromochloropropane	0.980	FC1D	08/23/93	< 0.463	NA
Dicyclopentadiene	0.450	FC2D	08/29/93	< 0.410	NA
Dimethyldisulfide	< 0.220	NA	NA	< 0.220	NA
Ethylbenzene	14.120	SQ1	12/08/92	0.924	FC3
Toluene	87.560	SQ1	12/08/92	6.383	FC3
Methyl isobutyl ketone	< 0.740	NA	NA	< 0.740	NA
Tetrachloroethene	16.780	SQ1	12/08/92	0.782	AQ5
Trichloroethene	0.657	SQ1	12/08/92	0.068	FC3
Xylenes	51.390	SQ1	12/08/92	4.701	FC3

μg/m^3 - micrograms per cubic meter
< ### - indicates average concentration is less than the lower certified reporting limit

NA - not applicable
* - AQ1 and AQ4 measured higher averages (see Table 4.6-2); however, these were based on limited samples, 5 and 3 cases respectively, while the AQ6 annual average was based on 71 cases.

analytes were all measured on December 8, 1992, prior to the operation of the SQI. As will be discussed in Section 4.6.5, these concentrations were part of the severe brown cloud influx from metropolitan Denver resulting from an intense surface inversion over the area. Two VOC analytes unique to Basin F, bicycloheptadiene and dicyclopentadiene, measured their highest FY93 24-hour concentrations at Basin F station FC2D; however, concentration levels were one to two orders of magnitude below peak levels detected during Basin F remediation. Comparisons of Basin F remediation levels and FY93 levels for VOCs will be discussed further in the next section.

4.6.3 Basin F Remediation Progress

The CMP/CAQMMP has monitored Basin F post-remedial air quality impacts continuously since the conclusion of the Basin F cleanup program in May of 1989. Routine VOC monitoring has been conducted each year at five or more sampling sites surrounding the remediation area. Seven remedial and post-remedial evaluation phases have been defined as shown in Table 4.1-1; FY93 is Phase 7 of this evaluation. Previous annual CMP reports have listed the sequential data for each post-remedial phase to assess remedial progress. It is now fairly well established that those VOC contaminants identified at higher concentrations during remediation have been reduced to near, or very slightly above, regional background levels. Changes in VOC ambient air concentration levels over the past several years have reflected, for the most part, regional air quality variations and other minor remediation activities at RMA, rather than continuing influences of Basin F. For the purpose of brevity in this report, Table 4.6-5 compares the annual average and 24-hour maximum VOC concentrations at Basin F stations during the Phase 1 and Phase 2 (Stage 1) remediation periods with the most recent Phase 7 post-remediation period (rather than including data from all of the other post-remedial phases). For those VOCs that have been identified as potential Basin F source emissions, FY93 concentration levels are significantly reduced or below detection levels. This is demonstrated graphically in Figure 4.6-1, which shows comparisons between Phase 1 remediation average concentrations for bicycloheptadiene, chloroform, dicyclopentadiene, dimethylsulfide, and toluene, and FY93 Phase 7 results. Also noted from these data (Table 4.6-5) is the decrease in concentration levels (even during Phase 1)

Table 4.6-5 Summary of Average Volatile Organic Compound Results for Phases 1, 2-1, and 7 ($\mu g/m^3$)

Site	Phases	111TCE	112TCE	11DCLE	12DCLE	12DCE	BCHPD	C6H6	CCL4	CH2CL2	CHCL3
BF1/FC1	Phase 1	9.44	ND	ND	0.04	ND	1.82	2.45	0.65	10.48	2.14
	Phase 2 Stage 1	5.50	ND	ND	ND	ND	0.25	3.97	1.04	4.01	0.77
	Phase 7	1.94	ND	ND	0.03	ND	0.04	3.30	0.78	8.48	1.12
BF2/FC2	Phase 1	8.05	ND	0.02	0.30	ND	9.96	3.49	0.61	7.57	6.95
	Phase 2 Stage 1	5.85	ND	ND	0.06	ND	0.88	3.79	0.92	2.52	1.89
	Phase 7	1.89	ND	ND	0.04	ND	0.09	2.65	0.74	7.67	1.76
BF3/FC3	Phase 1	6.94	ND	ND	0.03	ND	0.49	1.94	0.52	7.17	0.80
	Phase 2 Stage 1	5.03	ND	ND	0.02	ND	0.09	3.32	0.88	3.52	0.48
	Phase 7	1.78	ND	ND	0.04	ND	0.03	2.99	0.58	2.26	0.72
BF4/FC4	Phase 1	10.53	0.05	ND	ND	ND	0.55	2.54	0.42	6.36	0.91
	Phase 2 Stage 1	5.22	ND	ND	0.03	ND	0.13	3.78	0.75	3.64	0.39
	Phase 7	2.20	ND	ND	0.05	ND	ND	3.34	0.75	2.36	0.56
BF5	Phase 1	8.54	ND	ND	0.03	ND	0.43	2.19	0.53	7.77	0.88
	Phase 2 Stage 1	4.18	ND	ND	0.02	ND	0.47	2.45	0.97	2.12	0.33
	Phase 7	*	*	*	*	*	*	*	*	*	*
FC5	Phase 1	*	*	*	*	*	*	*	*	*	*
	Phase 2 Stage 1	*	*	*	*	*	*	*	*	*	*
	Phase 7	1.78	ND	ND	0.03	ND	0.04	2.52	0.74	8.36	1.00

* Samples not collected at this site.
ND Not detected.
$\mu g/m^3$ Micrograms per cubic meter
Note: Phase 1 is from March 22 to December 12, 1988.
Phase 2, Stage 1 is from December 13, 1988 to February 15, 1989.
Phase 7 is from October 1, 1992 to September 30, 1993.

111TCE - 1,1,1-Trichloroethane
112TCE - 1,1,2-Tricholorethane
11DCLE - 1,1-Dichloroethane
12DCLE - 1,2-Dichloroethane
12DCE - trans-1,2-Dichloroethene
BCHPD - Bicycloheptadiene
C6H6 - Benzene
CCL4 - Carbon Tetrachloride
CH2CL2 - Methylene Chloride
CHCL3 - Chloroform

RMA/0978 10/19/94 3:05 pm bpw

Table 4.6-5 Summary of Average Volatile Organic Compounds Results for Phases 1, 2-1, and 7 ($\mu g/m^3$)

Site	Phases	CLC6H5	DBCP	DCPD	DMDS	ETC6H5	MEC6H5	MIBK	TCLEE	TRCLE	XYLENES
BF1/FC1	Phase 1	0.05	*	1.60	7.86	1.09	9.34	ND	2.12	0.26	5.61
	Phase 2 Stage 1	0.02	*	0.45	ND	1.59	5.24	ND	1.55	0.17	6.75
	Phase 7	ND	ND	ND	ND	0.69	5.45	ND	0.63	0.05	3.31
BF2/FC2	Phase 1	0.12	*	4.53	5.34	1.58	20.95	ND	5.07	0.12	8.57
	Phase 2 Stage 1	0.03	*	0.32	0.02	1.49	5.05	ND	1.57	0.11	6.35
	Phase 7	ND	ND	ND	ND	0.64	4.78	ND	0.64	0.04	3.09
BF3/FC3	Phase 1	ND	*	0.52	0.50	0.81	8.27	ND	1.13	0.21	4.23
	Phase 2 Stage 1	ND	*	0.18	ND	1.45	4.81	ND	1.37	0.15	6.40
	Phase 7	ND	ND	ND	ND	0.92	6.38	ND	0.70	0.07	4.20
BF4/FC4	Phase 1	0.03	*	0.48	0.91	0.92	8.51	ND	1.13	0.29	5.02
	Phase 2 Stage 1	ND	*	0.21	ND	1.94	5.02	ND	1.59	0.17	8.17
	Phase 7	ND	ND	ND	ND	0.86	6.07	ND	0.77	0.06	4.26
BF5	Phase 1	0.02	*	0.34	0.92	0.77	5.47	ND	1.21	0.24	3.94
	Phase 2 Stage 1	ND	*	0.06	ND	0.85	3.30	ND	0.94	0.09	3.72
	Phase 7	*	*	*	*	*	*	*	*	*	*
FC5	Phase 1	*	*	*	*	*	*	*	*	*	*
	Phase 2 Stage 1	*	*	*	*	*	*	*	*	*	*
	Phase 7	ND	ND	ND	ND	0.61	4.58	ND	0.55	0.04	2.91

* Samples not collected at this site.
ND Not detected.
$\mu g/m^3$ Micrograms pwer cubic meter
Note: Phase 1 is from March 22 to December 12, 1988.
Phase 2, Stage 1 is from December 13, 1988 to February 15, 1989.
Phase 7 is from October 1, 1992 to September 30, 1993.

CLC6H5 - Chlorobenzene
DBCP - Dibromochloropropane
DCPD - Dicyclopentadiene
DMDS - Dimethyldisulfide
ETC6H5 - Ethylbenzene
MEC6H5 - Toluene
MIBK - Methyl isobutyl ketone
TCLEE - Tetrachloroethene
TRCLE - Trichloroethene
XYLENES - Total Xylenes

RMA/0978 10/19/94 3:05 pm bpw

Table 4.6-5 Summary of 24-Hour Maximum Volatile Organic Compound Results for Phases 1, 2-1, and 7 ($\mu g/m^3$)

Site	Phases	111TCE	112TCE	11DCLE	12DCLE	12DCE	BCHPD	C6H6	CCL4	CH2CL2	CHCL3
BF1/FC1	Phase 1	72.54	ND	ND	0.23	ND	17.98	6.89	3.89	54.80	18.51
	Phase 2 Stage 1	9.45	ND	ND	ND	ND	1.77	8.87	1.93	23.52	3.24
	Phase 7	6.16	ND	ND	0.07	ND	0.21	31.43	2.10	293.02	5.07
BF2/FC2	Phase 1	53.40	ND	0.08	1.89	ND	39.46	10.83	6.68	55.34	37.15
	Phase 2 Stage 1	17.47	ND	ND	0.59	ND	6.66	7.78	2.21	15.73	16.41
	Phase 7	6.51	ND	ND	0.25	ND	0.63	13.49	1.47	184.70	4.87
BF3/FC3	Phase 1	62.88	ND	ND	0.24	ND	2.69	5.20	4.00	57.64	3.11
	Phase 2 Stage 1	11.48	ND	ND	0.11	ND	0.85	6.83	2.52	23.71	1.19
	Phase 7	2.83	ND	ND	0.16	ND	0.06	7.14	0.02	11.56	1.79
BF4/FC4	Phase 1	67.00	1.12	ND	ND	ND	12.25	6.52	5.61	58.14	18.03
	Phase 2 Stage 1	15.74	ND	ND	0.24	ND	1.51	8.97	1.30	19.77	0.92
	Phase 7	3.93	ND	ND	0.18	ND	ND	8.56	1.15	10.46	1.20
BF5	Phase 1	40.48	ND	ND	0.15	ND	2.64	6.82	1.19	50.81	5.65
	Phase 2 Stage 1	8.55	ND	ND	0.12	ND	7.27	4.71	1.59	6.51	0.75
	Phase 7	*	*	*	*	*	*	*	*	*	*
FC5	Phase 1	*	*	*	*	*	*	*	*	*	*
	Phase 2 Stage 1	*	*	*	*	*	*	*	*	*	*
	Phase 7	5.09	ND	ND	0.14	ND	0.17	9.21	2.35	273.3	2.91

* Samples not collected at this site.
ND Not detected.
$\mu g/m^3$ Micrograms per cubic meter
Note: Phase 1 is from March 22 to December 12, 1988.
Phase 2, Stage 1 is from December 13, 1988 to February 15, 1989.
Phase 7 is from October 1, 1992 to September 30, 1993.

111TCE - 1,1,1-Trichloroethane
112TCE - 1,1,2-Trichloroethane
11DCLE - 1,1-Dichloroethane
12DCLE - 1,2-Dichloroethane
12DCE - trans-1,2-Dichloroethene

BCHPD - Bicycloheptadiene
C6H6 - Benzene
CCL4 - Carbon Tetrachloride
CH2CL2 - Methylene Chloride
CHCL3 - Chloroform

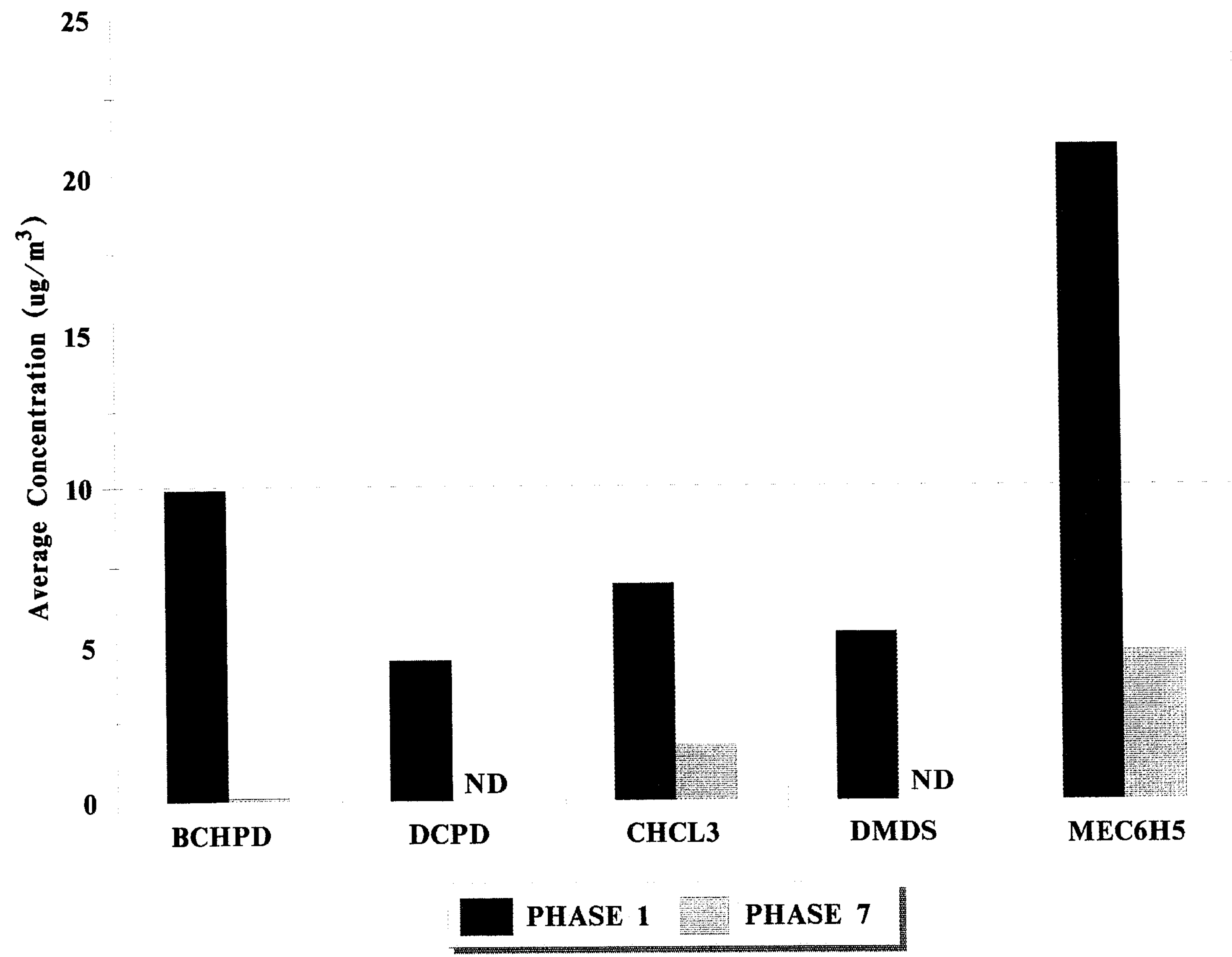
RMA/0979 10/06/94 9:04 am bpw

Table 4.6-5 Summary of 24-Hour Maximum Volatile Organic Compounds Results for Phases 1, 2-1, and 7 ($\mu g/m^3$)

Site	Phases	CLC6H5	DBCP	DCPD	DMDS	ETC6H5	MEC6H5	MIBK	TCLEE	TRCLE	XYLENES
BF1/FC1	Phase 1	0.45	*	4.58	36.72	4.95	35.55	ND	16.02	1.47	25.94
	Phase 2 Stage 1	1.55	*	3.36	ND	4.38	13.32	ND	3.19	0.57	17.26
	Phase 7	ND	ND	ND	ND	4.06	32.09	ND	5.63	0.25	18.61
BF2/FC2	Phase 1	0.80	*	29.12	24.06	8.91	90.10	ND	23.17	0.78	49.91
	Phase 2 Stage 1	0.06	*	2.48	0.08	4.20	11.43	ND	4.48	0.34	15.77
	Phase 7	ND	ND	ND	ND	3.74	24.19	ND	5.02	0.20	19.54
BF3/FC3	Phase 1	ND	*	6.04	4.97	3.98	49.41	ND	2.30	1.00	10.51
	Phase 2 Stage 1	ND	*	1.27	ND	3.75	11.14	ND	2.83	0.34	15.57
	Phase 7	ND	ND	ND	ND	2.15	13.84	ND	1.39	0.16	11.70
BF4/FC4	Phase 1	0.39	*	3.74	8.07	2.39	49.91	ND	3.40	1.81	10.39
	Phase 2 Stage 1	ND	*	1.37	ND	8.97	19.52	ND	5.52	0.65	28.28
	Phase 7	ND	ND	ND	ND	2.32	17.57	ND	2.26	0.14	13.00
BF5	Phase 1	0.05	*	2.15	3.95	2.48	14.49	ND	3.32	1.00	10.52
	Phase 2 Stage 1	ND	*	0.60	ND	1.99	8.42	ND	2.58	0.17	10.39
	Phase 7	*	*	*	*	*	*	*	*	*	*
FC5	Phase 1	*	*	*	*	*	*	*	*	*	*
	Phase 2 Stage 1	*	*	*	*	*	*	*	*	*	*
	Phase 7	ND	ND	ND	ND	4.35	23.83	ND	3.30	0.18	20.36

* Samples not collected at this site.
ND Not detected.
$\mu g/m^3$ Micrograms per cubic meter
Note: Phase 1 is from March 22 to December 12, 1988.
Phase 2, Stage 1 is from December 13, 1988 to February 15, 1989.
Phase 7 is from October 1, 1992 to September 30, 1993.

CLC6H5 - Chlorobenzene
DBCP - Dibromochloropropane
DCPD - Dicyclopentadiene
DMDS - Dimethyldisulfide
ETC6H5 - Ethylbenzene
MEC6H5 - Toluene
MIBK - Methyl isobutyl ketone
TCLEE - Tetrachloroethene
TRCLE - Trichloroethene
XYLENES - Total Xylenes



BCHPD - Bicycloheptadiene
DCPD - Dicyclopentadiene
CHCL3 - Chloroform
DMDS - Dimethyldisulfide
MEC6H5 - Toluene
ND - Not detected during this phase

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Figure 4.6-1

FC2 Average VOC Concentration for Phases 1 and 7

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with distance from the Basin F source (e.g., BF2 versus BF5). This suggests that Basin F was the principal source of these contaminants and that impacts were localized and decreased beyond the immediate vicinity of the remediation activities.

Another approach to assessing Basin F impacts is to evaluate monitoring data during worst-case meteorological conditions. During active remediation periods, higher concentrations for many contaminants were downwind from the flow across Basin F, and were also consistent with air dispersion modeling evaluations using Basin F as a potential area source. Several Basin F air monitoring scenarios continue to be employed in the high-event program (to be discussed in the next section) and, as will be noted, significant concentrations of contaminants are no longer discovered downwind from Basin F, though on occasion some residual levels above baseline are measured.

4.6.4 VOC High-Event Monitoring

VOCs were monitored in FY93 routinely, bi-weekly, monthly, seasonally, and also in accordance with high-event, worst-case meteorological conditions. For the most part, the identification of high events for VOCs attempted to meet specified meteorological criteria, e.g., temperatures above 75°F at the start of the monitoring period and winds less than 5 mph. Since the wind criteria of less than 5 mph was extremely difficult to predict during the summer seasons, especially during mid-afternoon when convective activity was at its highest levels, emphasis, as in the past, was placed on mobilizing for light wind days, generally between 5 and 8 mph. Because of the variability of light winds, each high-event monitoring episode concentrated on a particular potential source with several samplers, including mobile monitors, surrounding the source area.

Experience with earlier CMP/CAQMMP programs also formed the basis for modifications and improvements to the high-event program. Although VOC monitoring was initiated on very warm days with temperatures in excess of 75°F, the monitoring was generally continued though the 24-hour period in order to capture the impacts of VOCs released under the warm temperatures and

then trapped under inversion conditions. Table 4.6-6 provides a summary of the FY93 high-event program for VOCs, including dates, selected target areas, sampling duration, and the sampling sites employed.

Also, in the past several years the interpretation of the high-event program has been broadened to include not only worst-case meteorological conditions but also special activities or contingency events that might warrant special monitoring (such as a leaking valve or pipeline). To the extent possible, appropriate meteorological conditions were sought, but in certain instances this was not possible.

FY93 VOC high-event episodes are described in the following sections. Several cases of interest are further illustrated in figures including selected ambient concentrations, wind roses, and dispersion modeling as appropriate. For those cases not illustrated, a detailed listing of all concentrations for the day of the event is provided in Appendix E.

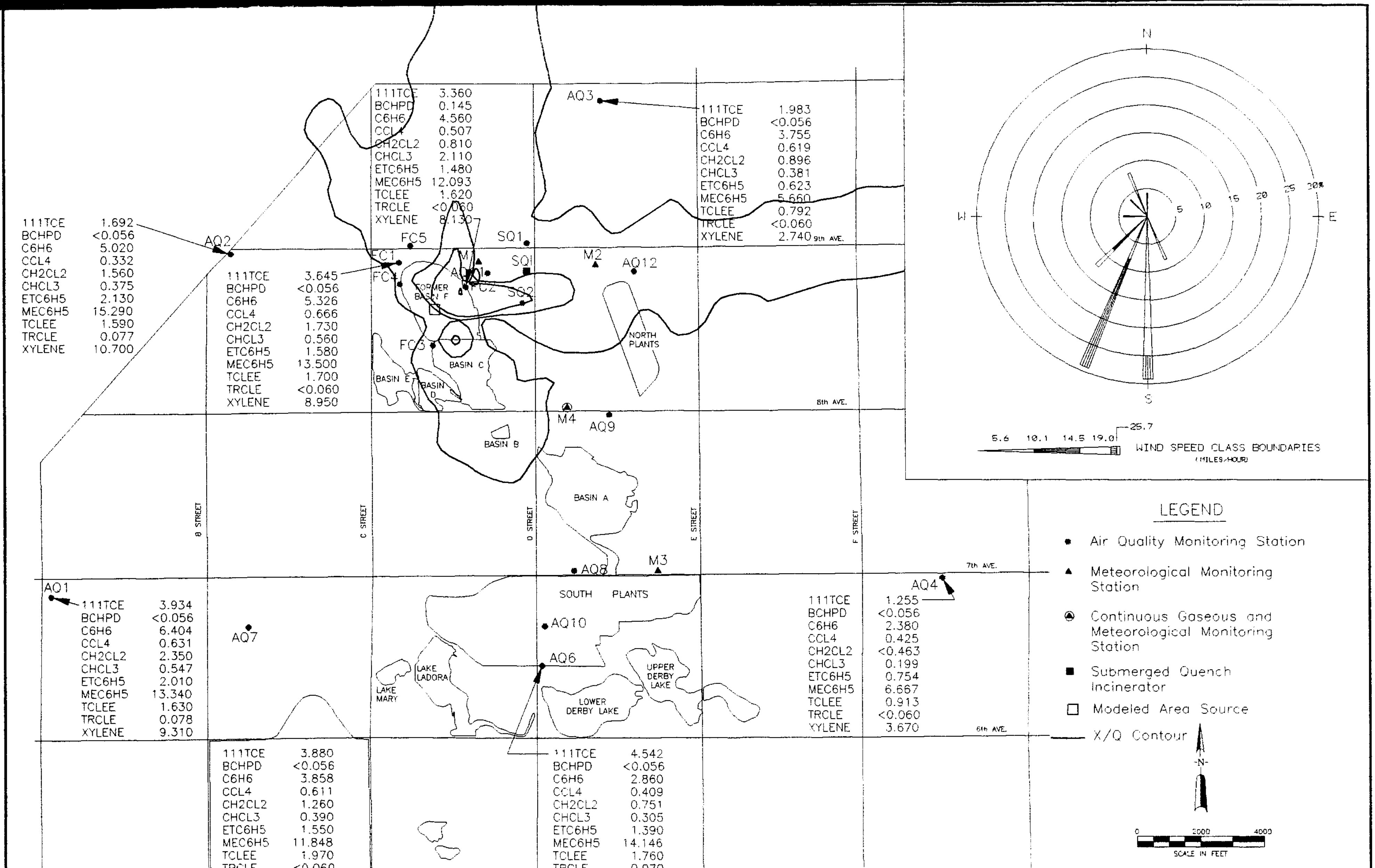
4.6.4.1 December 11, 1993—Seasonal High-Event

This was a late fall VOC seasonal high-event (the Technical Plan requires four such seasonal events). On this day, the winds were moderate to strong and persistently from the south. Temperatures ranged from below freezing to near 50°F at mid day. All the RMA perimeter sites were sampled and Basin F was also targeted with two downwind sampling sites. The highest levels of benzene, methylene chloride, and trichloroethene were measured at AQ1 on the western perimeter; the highest levels of toluene, ethylbenzene, and total xylenes were measured at the northwest perimeter site AQ2; and the highest tetrachloroethene was measured at perimeter site AQ5 at the southern boundary. 1,1,1-trichloroethane was highest at AQ6 in the southern portion of RMA; accordingly, with the wind flow as shown in Figure 4.6-2, it would appear that the source of this contamination is metropolitan Denver. Since this day was three days after the previously described severe pollution/inversion day of December 8, 1992, some residual air quality impacts may still have been evident. Two contaminants were identified as potential Basin F source emissions: 1) bicycloheptadiene was measured downwind from Basin F at FC2

Table 4.6-6 FY93 Volatile Organic Compound High-Event Sampling Locations

Date	Target Area	Duration	Sampling Locations
12/11/92	Basin F and Seasonal	1100-1100	AQ1, AQ2, AQ3, AQ4, AQ5, AQ6, FC1, FC2
2/24/93	Seasonal	1200-1200	AQ1, AQ4
3/4/93	Submerged Quench Incinerator (Baseline)	1200-1200	AQ2, AQ3, AQ4, AQ5, AQ6, FC2, SQ1, SQ2, M1E
5/13/93	Hydrazine Plant	1100-1100	AQ2, AQ6, M201W, M301N, M401E, M501S
6/3/93	Seasonal	1100-1100	AQ1, AQ4
6/12/93	Submerged Quench Incinerator (Trial Burn)	0700-0700	AQ3, AQ6, SQ1, SQ2, FC2, M125W
6/24/93	Basin F Excavation Activities	1300-1300	AQ5, AQ8, AQ9, FC1, M336E, M436W
6/30/93	Basin F	1100-1100	FC1, FC2, FC3, FC4, AQ11, M226E
7/15/93	Basin A Soil Sifting	0700-1500 (8 hours)	AQ1, AQ4, AQ5, AQ9, AQ10, M601N, M701N
7/30/93	Section 27 Water Treatment Plant	1000-1000	AQ2, FC1, FC2, M122SW, M127NW, M227NW, AQ1
8/11/93	South Plants Area	1200-1200	AQ5, AQ6, AQ8, AQ9, M801N, M102E
8/29/93	Submerged Quench Incinerator	1300-1300	AQ3, AQ6, SQ1, SQ2, FC2, M225W
9/12/93	Basin F Waste Pile	1200-1200	FC2, FC3, FC4, M326E, M426S, M526SE

RMA/0980 06/01/94 11:19 am bpw



111TCE – 1,1,1-Trichloroethane
BCHPD – Bicycloheptadiene
C6H6 – Benzene
CCL4 – Carbon Tetrachloride
CH2CL2 – Methylene Chloride
CHCL3 – Chloroform
ETC6H5 – Ethylbenzene
MEC6H5 – Toluene
TCLEE – Tetrachloroethene
TRCLE – Trichloroethene
XYLENE – Total Xylenes

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Figure 4.6–2
VOC Results (ug/m^3) and X/Q Dispersion Pattern for 12/11/92

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(and FC2D, not shown), and 2) chloroform was measured at highest levels at both FC2 and FC1. Bicycloheptadiene, a contaminant unique to Basin F, was measured at a low level, 0.154 $\mu g/m^3$, on this less than ideal meteorological day for VOC detection. Carbon tetrachloride was also highest at FC1 but the concentration level was comparable to perimeter sites. Figure 4.6-2 provides a display of all concentrations, the atmospheric dispersion pattern and the 24-hour wind rose for this day. Note that FC1, and particularly FC2, are within the potential impact of Basin F as reflected by the X/Q contours from a theoretical Basin F area source.

4.6.4.2 February 24, 1993—Basin F (also Seasonal High-Event)

On this day, VOCs were measured at four Basin F sites, the SQI sites, and RMA perimeter sites. Winds were primarily from the north (see Figure 4.6-3) and temperatures were in the low 30s. Winds were light (2 to 3 mph) through much of the sampling period. Higher levels of 1,1,1-trichloroethane, carbon tetrachloride, methylene chloride, and chloroform were all measured at Basin F Site FC5; other maximum values were primarily at boundary sites. It is difficult to explain the higher concentrations at FC5 as winds were exclusively from the north, upwind from the Basin F area. An explanation may be its close proximity to Pond A, or possibly the recirculation of contaminants in the Denver metropolitan basin under persistent light winds and drainage conditions on this day.

4.6.4.3 March 4, 1993—Submerged Quench Incinerator

On this day, VOC high-event monitoring was conducted to investigate the SQI area baseline prior to operation of the incinerator. Monitoring was conducted north and south of the SQI at SQ1 and SQ2, respectively, west of the SQI at FC2, and east of the SQI at a mobile site, M1E. Temperatures were in the 40s, and winds were from the northeast at moderate to light speeds. Most VOC concentrations were either below detection, below average, or near baseline levels, except carbon tetrachloride, which was measured at 0.926 $\mu g/m^3$, slightly above the annual average value, and 1,2-dichloroethane which was measured at a low concentration level, 0.078 $\mu g/m^3$; both were measured at FC2. There appeared to be no significant baseline impacts in the SQI area.

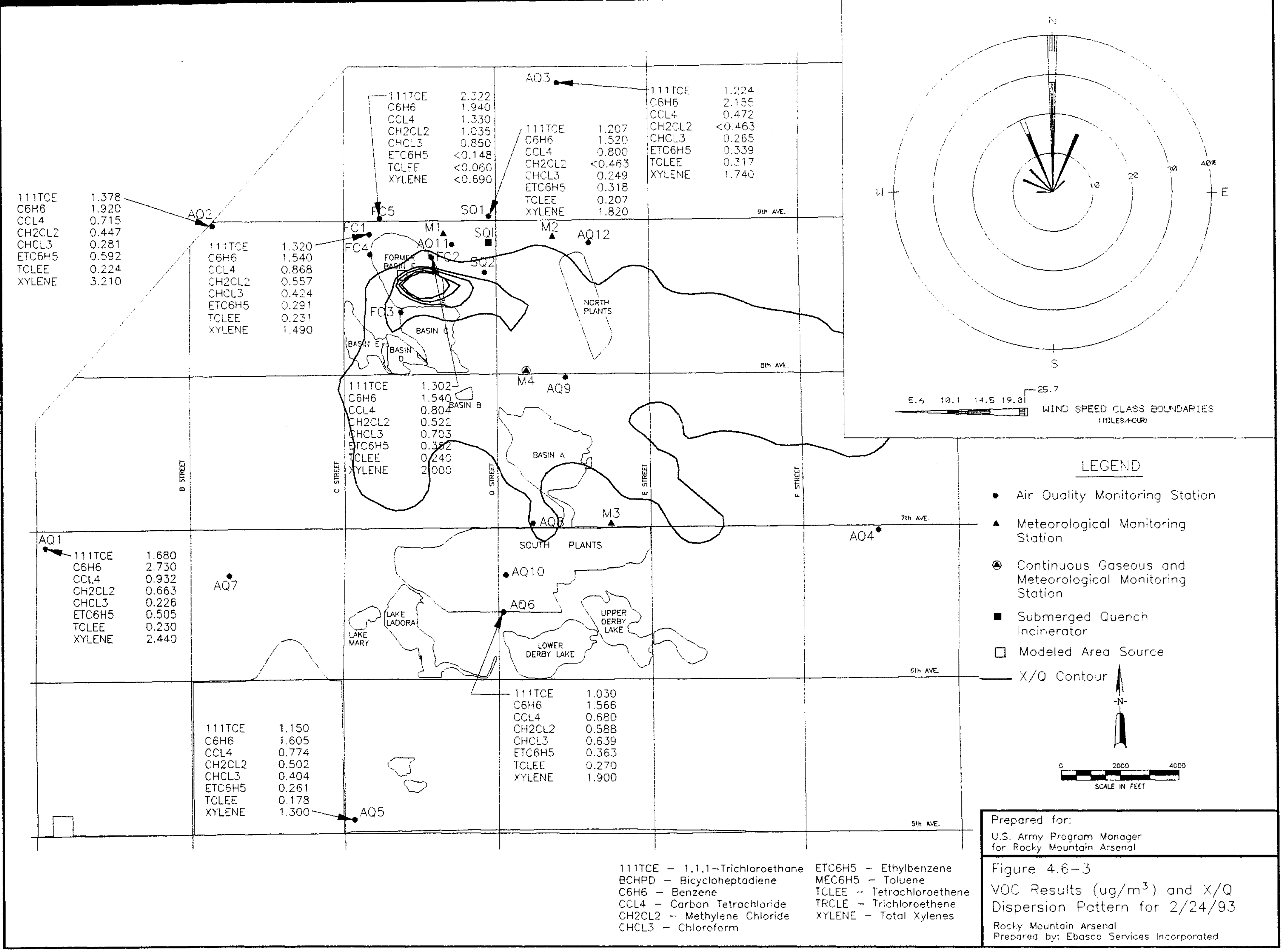

Figure 4.6–3
VOC Results (ug/m^3) and X/Q Dispersion Pattern for 2/24/93

4.6.4.4 May 13, 1993—Hydrazine Plant Area

On this day, high-event monitoring was conducted in the vicinity of the remediated hydrazine plant area where VOC contaminants had previously been identified. Extensive monitoring was conducted as this high event also coincided with a routine sampling day. Four mobile sites surrounded the old hydrazine area (M301N, M501S, M4013, and M201W), and the program included SQ1, SQ2, AQ2, AQ3, AQ5 and AQ6. Winds were primarily from the southeast on this day and were moderate to light. Temperatures reached the low 70s (see Figure 4.6-4).

Several results of interest were noted on this sampling day. The old hydrazine plant area, which was the principal area of investigation, indicated little or no residual VOC impacts, however, slightly higher concentrations for several VOCs occurred at FC1 downwind from the remediated Basin F area. These included ethylbenzene, benzene, carbon tetrachloride, chloroform, and xylene. This was a more favorable high-event sampling day than the previous fall and winter sampling events and suggests that Basin F remains a low-level source for several VOCs. Note that the VOC potential source in the figure is centered over the old hydrazine plant area. If the source were centered over Basin F, the higher X/Q contours shown in Figure 4.6-4 would coincide with the location of Station FC1.

Of particular interest on this day were the moderate-to-high levels of methylene chloride which had begun to be measured at RMA sites starting in April 1993 and continuing to mid-June 1993. This compound was measured at all RMA sites with the lowest levels at the hydrazine sites and the highest levels at perimeter sites AQ5 and AQ2, which measured 52.6 $\mu g/m^3$ and 52.0 $\mu g/m^3$ respectively. High methylene chloride concentration levels will be discussed further in Section 4.6.5.2.

4.6.4.5 June 3, 1993—Seasonal High-Event

This was a late spring seasonal high-event that included perimeter sites AQ1, AQ3, AQ4, and the SQI special network. Temperatures were in the 60s and winds were moderate and

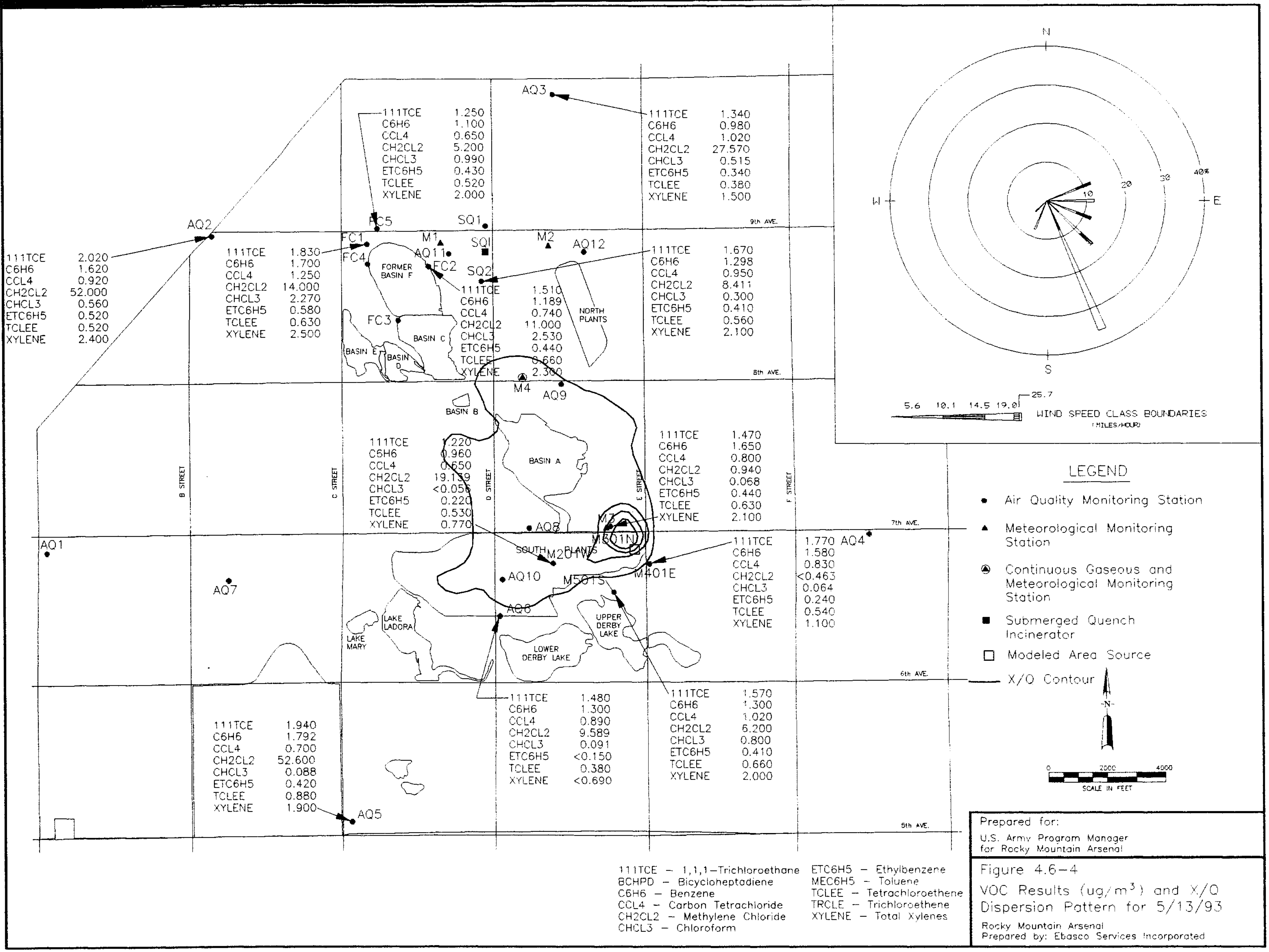

Figure 4.6-4
VOC Results (ug/m^3) and X/O Dispersion Pattern for 5/13/93

occasionally gusty. This was not an ideal day for high-event VOC monitoring and most analytes were reported at low or non-detectable levels. Of special interest on this day, however, was that very high methylene chloride concentrations were measured at all sites, including the highest level of the year, 560.0 $\mu g/m^3$ at AQ1, and 440 $\mu g/m^3$ at AQ6. This case study will be discussed further in Section 4.6.5.2 (and illustrated in Figure 4.6-9).

4.6.4.6 June 12, 1993—SQI Stack Testing

This was a follow-on high-event sampling episode at the SQI during a period when the facility was fully operational and undergoing special stack testing. Temperatures reached the low 80s during the monitoring period and winds were primarily from the south at low-to-moderate speeds. Monitoring was conducted at the SQI special network (SQ1, SQ2, AQ3, and AQ6), as well as at FC2 and FC5. Highest concentrations occurred at slightly above-average levels at the FC2 site. With respect to the SQI, levels at all sites were close to uniform. SQ2 concentrations to the south were slightly higher than SQ1 levels to the north. With winds primarily from the south, this would not suggest that the SQI facility was a source of VOCs. Methylene chloride was again measured at moderate levels with the highest levels, 29 $\mu g/m^3$, occurring at SQ2 and also at AQ3 on the northern perimeter. Complete results of the SQI special monitoring program are discussed in Section 4.6.10.

4.6.4.7 June 24, 1993—Basin A Excavation Activities

High-event monitoring was initiated on this day because of excavation activities in the Basin A area. Winds were moderate with occasional gusts and temperatures reached the upper 70s. Wind directions were from the north, east, and south with potential dispersion impacts to the northwest through southwest. Basin A was surrounded using AQ9 to the north, AQ8 to the south, and mobile sites to the east and west. Four FC sites were also sampled, as were perimeter sites AQ2 and AQ5. Most of the compounds appeared to be uniform upwind and downwind from the Basin A area. The one exception was chloroform which measured 4.0 $\mu g/m^3$ at AQ8. Chloroform has been identified in the Basin A and South Plants areas in previous sampling.

4.6.4.8 June 30, 1993—Basin F

This was a very broad high-event monitoring day that encompassed 15 sampling sites, including five Basin F sites; a mobile site, M226E, directly east of Basin F; the SQI interior sites; and three perimeter sites. Temperatures reached a maximum of 92°F and winds were moderate to light, primarily from the northeast. The dispersion pattern from a potential Basin F source spread across the remediated basin floor from northeast to southwest (see Figure 4.6-5). On this day many of the highest VOC concentrations were measured at Basin F sites, especially at FC3 downwind. As the wind was exclusively from the northeast quadrant on this day, and away from downtown Denver, the higher VOC levels could be attributed to residual impacts from Basin F. Nevertheless, as stated elsewhere, concentration levels were one or two orders of magnitude below peak remediation values. It is interesting that methylene chloride levels were all below detection except for one very low measurement of 0.710 $\mu g/m^3$ at FC3.

4.6.4.9 July 15, 1993—Basin A Soil Sifting Building 545, South Plants

This was an 8-hour VOC high-event episode during soil sifting activities in Building 545 in South Plants. Mobile monitoring sites were located close to the north, east, and west of the building; AQ10 to the south and AQ8 to the north were also used. Winds were exclusively from the northern quadrant on this day and were generally light; it is likely that there were variable wind circulations within the South Plant building complex. Temperatures reached the mid-80s. The case study is illustrated in Figure 4.6-6, with a potential VOC source in the area of Building 545. Although many VOC compounds were below detection, those that were measured, including toluene, tetrachloroethene, benzene, carbon tetrachloride, and chloroform, were all highest in the network surrounding Building 545. In particular, chloroform reached a peak level of 9.70 $\mu g/m^3$ at mobile site M601ND, 100 feet east of the building. A high chloroform level of 7.1 $\mu g/m^3$ was also measured at AQ8 just to the north of South Plants. With the winds exclusively from the northern quadrant, it would appear that the source of chloroform was the Basin A or Basin F areas. It is possible that there may have been close-in impacts from the soil sifting activities, but comparable levels of these compounds have previously been measured within the South Plants complex.

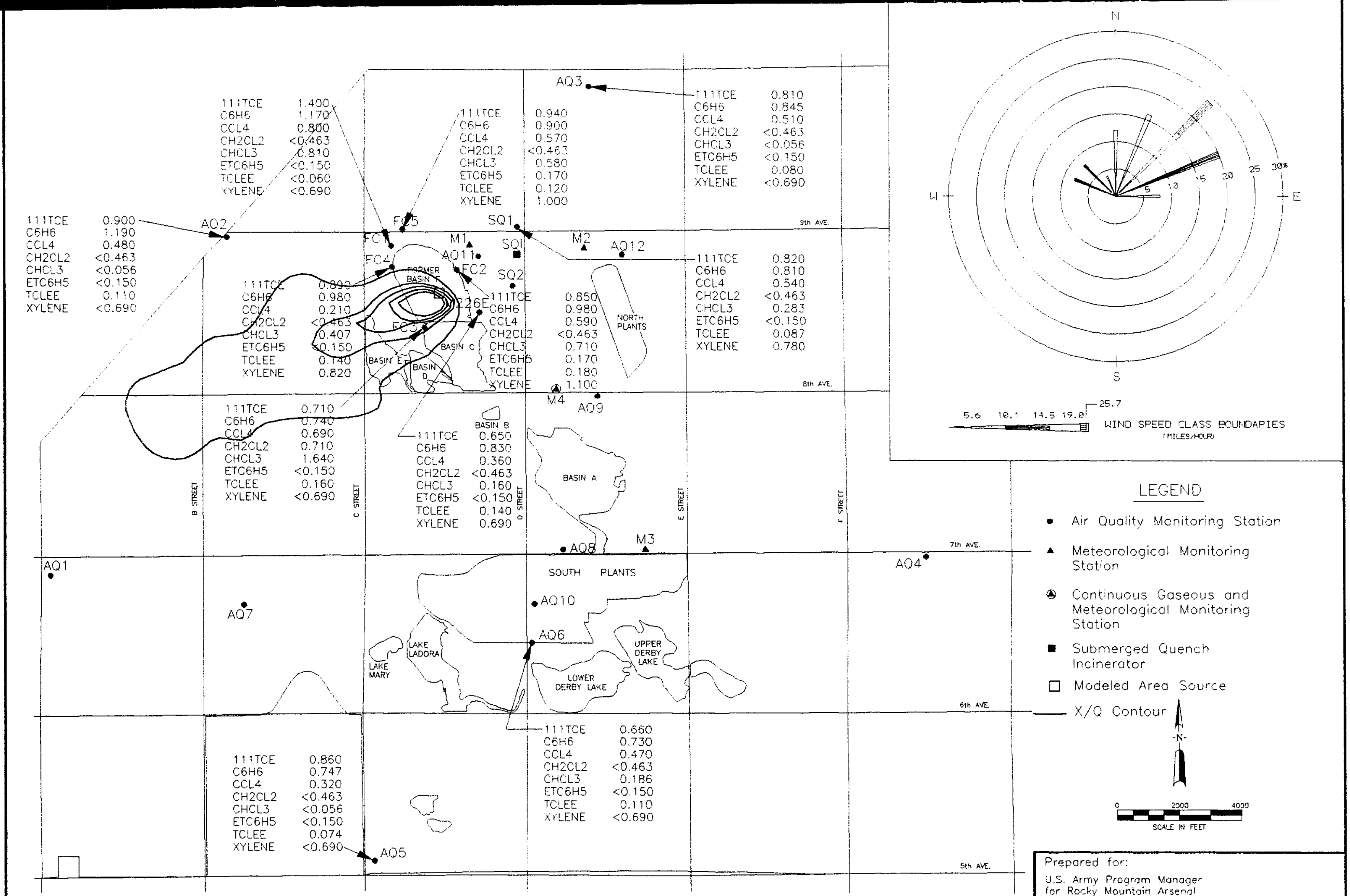

Figure 4.6-5

VOC Results (ug/m³) and X/O Dispersion Pattern for 6/30/93

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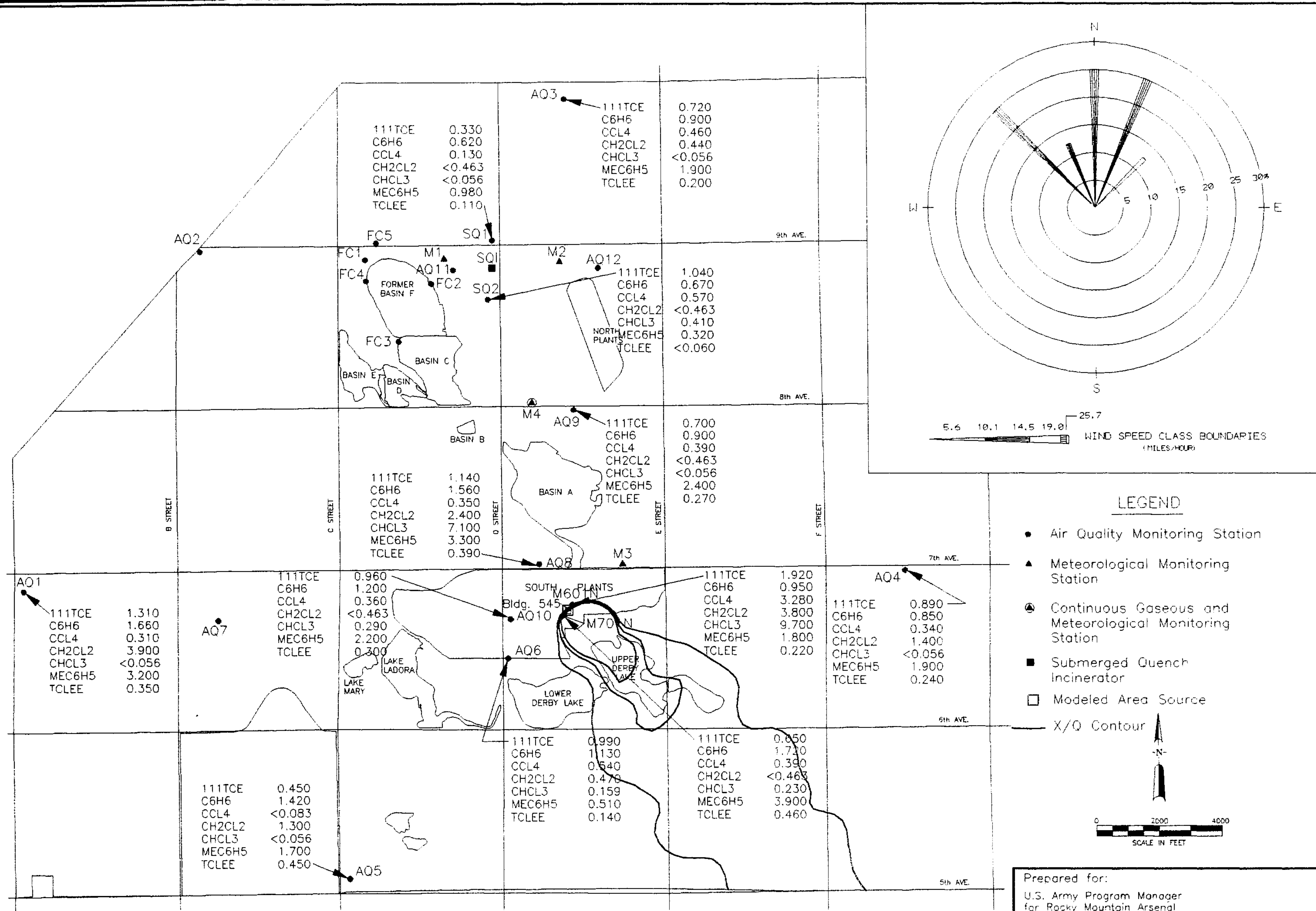

111TCE – 1,1,1-Trichloroethane
BCHPD – Bicycloheptadiene
C6H6 – Benzene
CCL4 – Carbon Tetrachloride
CH2CL2 – Methylene Chloride
CHCL3 – Chloroform
ETC6H5 – Ethylbenzene
MEC6H5 – Toluene
TCLEE – Tetrachloroethene
TRCLE – Trichloroethene
XYLENE – Total Xylenes

Prepared for:
U.S. Army Program Manager
for Rocky Mountain Arsenal

Figure 4.6-6
VOC Results (ug/m^3) and X/Q Dispersion Pattern for 7/15/93

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4.6.4.10 July 30, 1993—Section 27 Water Treatment Plant

At the request of RMA, high-event monitoring was conducted around the groundwater treatment plant in Section 27, at the northwest corner of RMA. Several mobile sampling stations, in addition to AQ2, were in close proximity to the facility. Winds were variable and generally light; temperatures reached the mid 90s. The highest concentrations for most compounds were measured at AQ5 at the south perimeter or at Basin F. Concentrations at the sites surrounding the water treatment site were below average with exception of toluene, which measured 5.20 $\mu g/m^3$ at mobile site M12714W, and also at nearby site AQ2. However, on this day, site AQ5 on the south perimeter measured a toluene level of 7.14 $\mu g/m^3$, indicating a broad source over the metropolitan area. Based on these data, the water treatment plant does not appear to be impacting the air quality in its vicinity.

4.6.4.11 August 11, 1993—South Plants

On this date, high-event monitoring was conducted at the South Plants. Winds were light to moderate and were bimodal in direction, from the southeast and northwest. Temperatures reached the low 80s. Monitoring was conducted at three mobile sites within the South Plants and at 13 other sampling sites across RMA. The highest VOC levels on this day were measured at perimeter sites AQ2 and AQ5 and at Basin F sites. South Plants mobile sites were comparable to levels measured at South Plants during the July 15 soil sifting activities (see Section 4.6.4.9 above) except for chloroform, which was very low on August 11 at the South Plants sampling sites compared to a peak level of 9.7 $\mu g/m^3$ on July 15. On the other hand, chloroform was again high at AQ8 reaching a maximum concentration of 10.00 $\mu g/m^3$; Basin F or Basin A could have been a source of chloroform emissions on this day.

4.6.4.12 August 29, 1993—SQI facility

On this day, high-event monitoring was conducted in the vicinity of the SQI and also at Basin F and perimeter sites. Winds were from the south-southeast through the northwest and were light to moderate. Temperatures reached the low 80s. The dispersion pattern indicated a potential

spread of pollutants from south to north. With respect to potential impacts from the SQI, VOC levels were low and there appeared to be little difference between concentrations at SQ1 north of the facility and SQ2 south of the facility. Several VOCs including benzene, ethylbenzene, toluene, tetrachloroethene, total xylenes, and bicycloheptadiene, measured values well above averages of this day in the vicinity of Basin F. This is illustrated in Figure 4.6-7. Of special interest, collocated passivated canisters were also tested on this day. Results were comparable with several individual exceptions. The canister tests will be discussed in Section 4.6.9.

4.6.4.13 September 12, 1993—Basin F

VOC high-event monitoring was conducted at Basin F on this date. Wind speeds were moderate to strong (this was conducted in conjunction with SVOC high-event monitoring where strong winds were a criteria sought), and temperatures reached the high 80s. Interestingly, all concentrations were considerably below the levels measured in the high-event episode 2 weeks earlier (Section 4.6.4.12). One explanation is that the winds were much stronger (reaching 30 mph) and not conducive to the trapping of VOCs, but this event also demonstrated the variability of VOCs at a given location, especially under variable meteorological conditions.

4.6.5 <u>Additional Special VOC Monitoring Results</u>

4.6.5.1 December 8, 1992

The above examples demonstrate the variability of VOC measurements across RMA, as well as the likelihood that some residual emissions exist in special areas such as Basin F, South Plants, and Basin A. It should be stressed that while higher concentrations of some VOCs are unique to areas such as Basin A and Basin F, they are well below levels that were achieved during active remediation. This can be put in a different perspective by examining potential impacts from metropolitan Denver, and particularly the consequences of an intense inversion day such as December 8, 1992 (which has been discussed previously). On this date, a very strong ground inversion existed over the Denver area for an extended period of time. Winds were light (under 5 mph) and primarily from the south. Temperatures remained below freezing the entire day. Figure 4.6-8 shows the VOC concentrations measured at RMA and the wind rose and dispersion

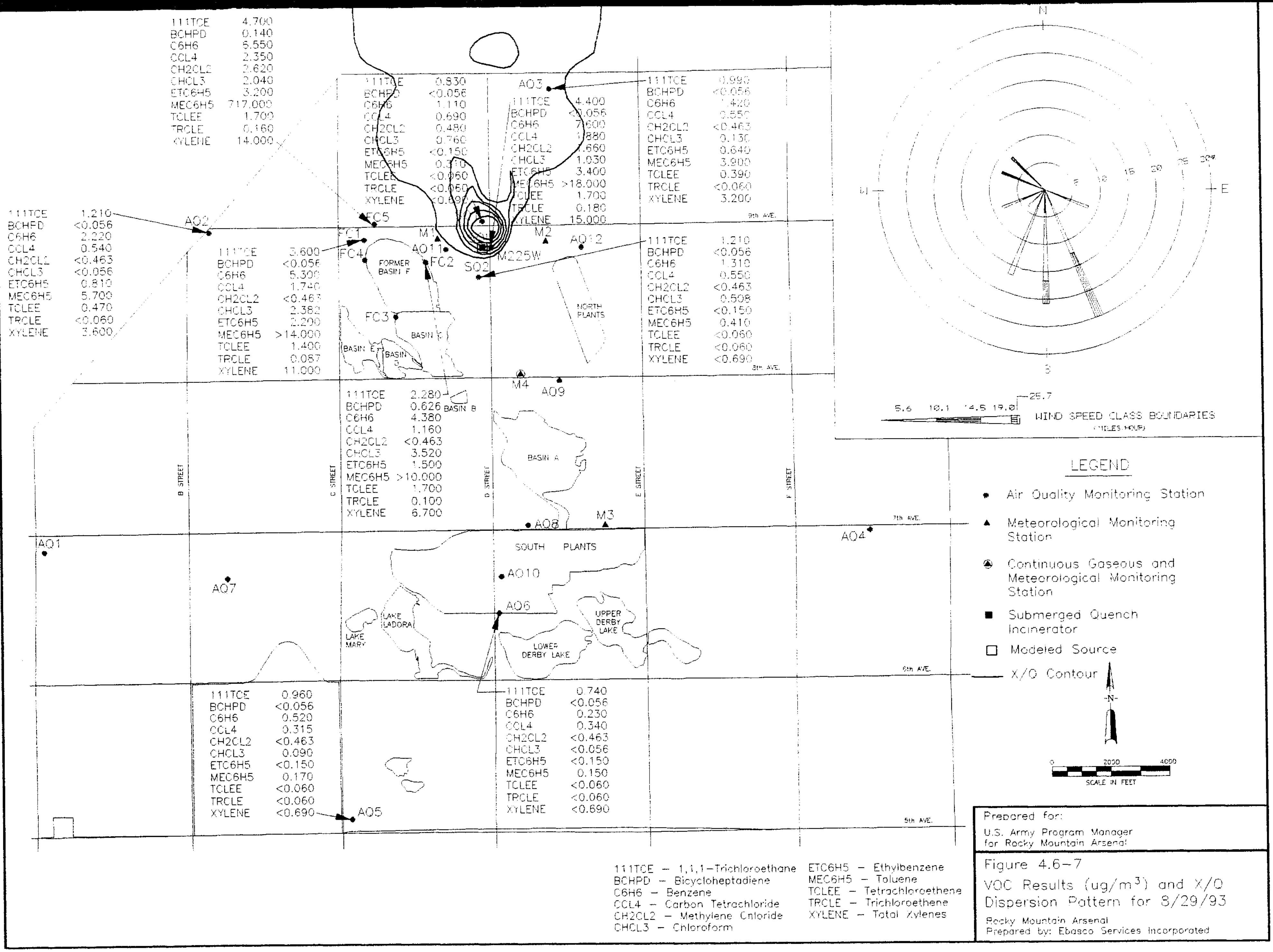

Figure 4.6-7
VOC Results (ug/m^3) and X/O Dispersion Pattern for 8/29/93

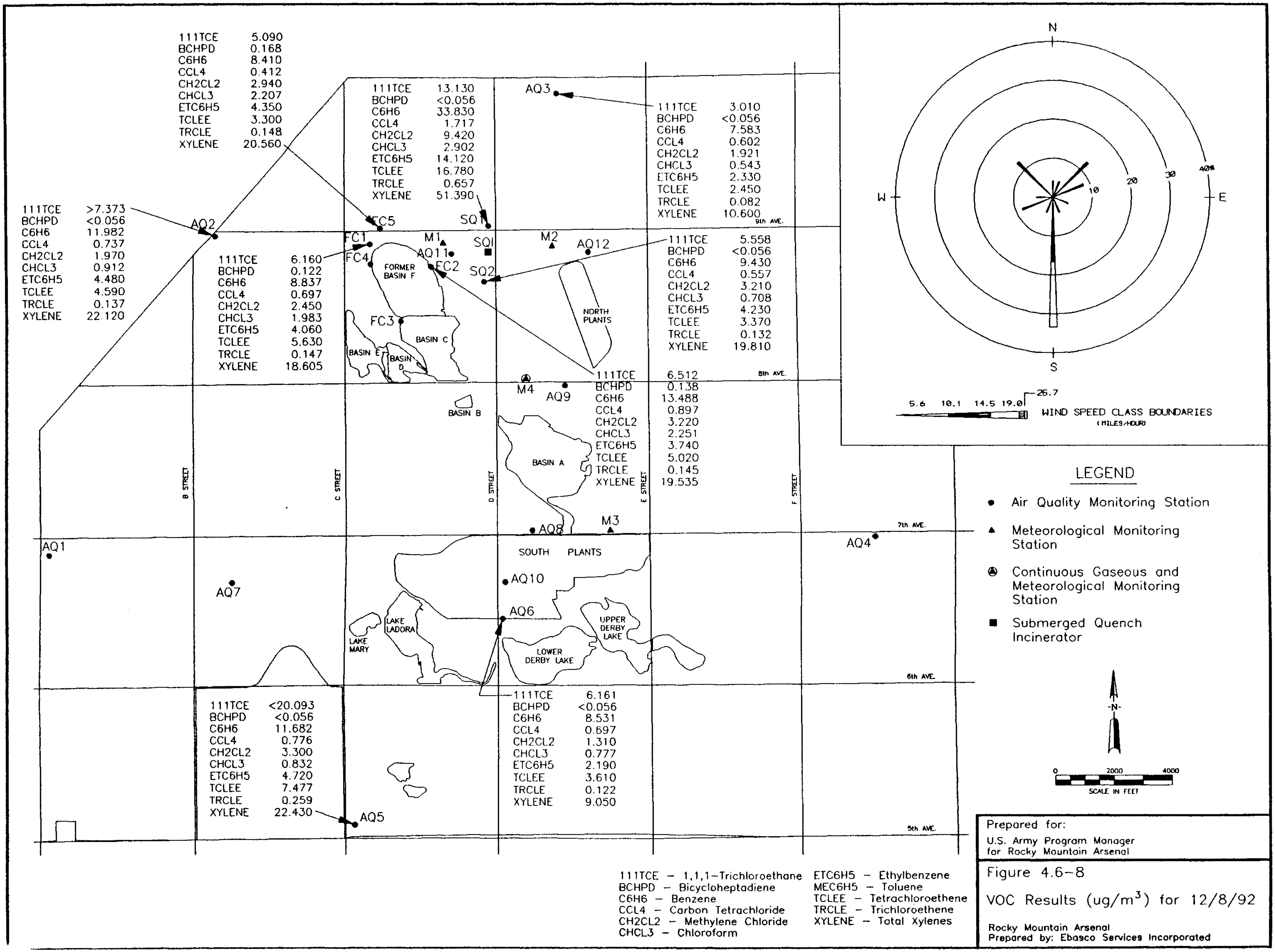

Figure 4.6-8

VOC Results (ug/m^3) for 12/8/92

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pattern; it can be assumed that the dispersion source was a broad area centered over downtown Denver and was advected to the north and over RMA. As discussed previously, the highest annual levels of TSP, PM-10, and criteria pollutants were measured in Denver and/or at RMA on this date. With respect to VOCs, seven compounds (1,1,1-trichloroethene, trichloroethene, tetrachloroethene, benzene, toluene, ethylbenzene, and total xylenes) measured their highest 24-hour maximum levels of the year on this date. Almost all individual stations measured peak values. Many concentrations were close to remediation peak levels and two, ethylbenzene and xylene, exceeded these levels.

In addition to the December 8, 1992 episode, several other analytes during FY93 measured annual peak values at RMA perimeter sites including chloroform, carbon tetrachloride, chlorobenzene, methylene chloride and 1,2-dichloroethane.

CDH and EPA do not routinely monitor VOCs in Denver, although several studies have been conducted, and an increasing regulatory effort has been made to identify metropolitan Denver VOC emission sources and toxicity levels. This information has appreciably assisted in interpreting and evaluating data collected under the CAQMMP. An interesting observation of the December 8, 1992 inversion episode is that the RMA monitoring network has, in essence, identified significant potential VOCs within the metropolitan air shed such as those analytes listed above (at least within the limitations of the CAQMMP VOC target list). Several target compounds historically identified at RMA were below detection during FY93 and one may conclude that they were not a factor in Denver or RMA during this year. Several other analytes discussed above (e.g., bicycloheptadiene and chloroform) undoubtedly represent unique local sources within RMA, but there may also be emission sources within the metropolitan area. One of the more challenging tasks of the CAQMMP is to identify the source of various pollutant constituents (including VOCs, metals, pesticides, and particulates) and to distinguish between on- and off-post sources. For example, methylene chloride is a compound that was observed (measured) at significant levels starting at about the middle of the FY93 program. The source

of these methylene chloride emissions is currently being investigated by the CAQMMP; results of initial investigations are discussed below.

4.6.5.2 Methylene Chloride Results and Analysis

During a period of several months in FY93, methylene chloride concentrations were measured at levels well above historical remediation and other RMA baseline average and maximum values. High concentrations were measured intermittently at almost all of the CAQMMP VOC sampling stations. Many 24-hour concentrations were in excess of 100 $\mu g/m^3$ and a maximum concentration of 556 $\mu g/m^3$ was measured at AQ1 on June 3, 1993. The previous maximum 24-hour level of methylene chloride was 434 $\mu g/m^3$ measured at BF3 during the Basin F remediation program (there was one other high concentration of 179 $\mu g/m^3$ at BF6 during the remediation program, and all other methylene chloride maximum levels were well below 100 $\mu g/m^3$).

Table 4.6-7 shows all methylene chloride concentrations measured at RMA between April 1, 1993 and July 12, 1993; during this time the third-day special sampling operations were conducted at Stations AQ3, AQ6, SQ1, and SQ2 to characterize the ambient air quality during startup of the SQI operations (see Section 4.6.10). Figure 4.6-9 shows the distribution of average and maximum 24-hour concentrations across RMA during this monitoring period (note, as shown in Table 4.6-7, the number of sampling days are different for individual stations). Finally, Figure 4.6-10 shows a bar graph of the maximum 24-hour concentrations for the same periods. The following interesting observations can be discerned from these data:

- High-to-moderate methylene chloride levels (in excess of 5 $\mu g/m^3$) occurred intermittently and were generally reflected at all the RMA sampling locations on the same day.
- Peak concentrations (in excess of 100 $\mu g/m^3$) occurred at almost all VOC sampling stations including perimeter sites AQ1, AQ2, AQ3, and AQ5; one time monitoring at AQ4 measured a methylene chloride concentration of 97 $\mu g/m^3$.

Table 4.6-7 Methylene Chloride Results (μg/m³)

Date	AQ1	AQ2	AQ3	AQ4	AQ5	AQ6	FC1	FC2	FC3	FC4	FC5	SQ1	SQ2	FBLK (μg)	Trip (μg)	FC1 Duplicate
4/1/93		< 0.463	< 0.463		< 0.463	< 0.463	< 0.463	< 0.463			< 0.463	< 0.463	< 0.463	< 0.100	< 0.100	< 0.463
4/7/93		0.523	1.060		3.386	2.586	0.614	2.090	2.240	3.460	2.320	0.972	1.700	0.358	< 0.100	1.310
4/13/93		4.103	2.582		6.908	6.217	2.552	2.518			1.710	13.574	1.047	0.198	< 0.100	1.991
4/16/93			73.783			2.950						61.822	56.468	0.284	< 0.100	
4/19/93		3.900	1.500		2.500	4.100	1.300	3.790			< 0.463	< 0.463	5.505	0.170	< 0.100	0.510
4/22/93			1.600			0.660						< 0.463	< 0.463	0.120	0.220	
4/25/93		< 0.463	< 0.463		0.490	< 0.463	< 0.463	< 0.463			< 0.463	< 0.463	< 0.463		< 0.100	< 0.463
4/28/93			> 4.630			< 0.463						< 0.463	< 0.463	< 0.100	< 0.100	
5/1/93		20.957	4.800		2.100	9.123	1.200	32.301			3.700	5.000	7.900	0.140	< 0.100	14.140
5/4/93			30.698			13.269						28.636	6.000	< 0.100	< 0.100	
5/7/93		100.437	11.538		21.127	78.431	44.390	65.909	11.556	10.455	27.014	10.423	13.980	< 0.100	< 0.100	12.084
5/10/93			25.860			8.700						16.071	30.000	< 0.100	< 0.100	
5/13/93		52.000	27.570		52.600	9.589	14.000	11.000			5.200	24.775	8.411		< 0.100	22.000
5/1693			16.200			7.000						16.100	10.500	< 0.100	< 0.100	
5/19/93		390.295	332.743		295.455	368.182	293.023	184.700			273.300	272.207	254.579	2.710	0.630	134.200
5/22/93			30.000			111.000						89.000	90.000	0.600	0.480	
5/25/93			8.790			21.740	2.400	14.100			14.600	8.019	4.408	< 0.100	< 0.100	1.100
5/28/93			3.660			1.800						2.070	3.800	0.400	< 0.100	
5/31/93		0.710	< 0.463		< 0.463	< 0.463	< 0.463	1.300			1.000	0.850	0.660	< 0.100	< 0.100	1.100
6/3/93	560.000		51.000	97.000		440.870						210.000	110.580	< 0.100	< 0.100	
6/6/93		70.000			14.540	31.000	20.200	28.000			37.000	16.900	30.000	0.170	0.430	34.000
6/9/93			395.000			31.640						305.000	191.000	0.350	< 0.100	
6/10/93			50.000			60.000						42.000	45.000	0.200	< 0.100	
6/11/93		40.560	29.200		2.300	4.700	14.100	4.100			10.000	27.500	29.100	< 0.100	< 0.100	
6/12/93			4.740			4.300						6.500	4.460	< 0.100	< 0.100	
6/15/93			2.150			3.550						2.600	2.650	< 0.100	< 0.100	
6/18/93		< 0.463	< 0.463		< 0.463	0.470	< 0.463	< 0.463	< 0.463	< 0.463	< 0.463	< 0.463	0.450	< 0.100	< 0.100	< 0.463
6/21/93			0.700			1.100						< 0.463	0.670	0.340	0.210	
6/24/93		< 0.463	< 0.463		< 0.463	0.900	< 0.463	2.570			5.300	< 0.463	< 0.463	0.016	< 0.100	1.500
6/30/93		< 0.463	< 0.463		< 0.463	< 0.463	< 0.463	< 0.463	0.710	< 0.463	< 0.463	< 0.463	< 0.463	< 0.100	0.130	< 0.463
7/6/93		< 0.463	< 0.463		< 0.463	< 0.463		0.900			0.540	< 0.463	1.100	0.280	< 0.100	< 0.463
7/9/93			< 0.463			< 0.463	< 0.463					< 0.463	< 0.463	< 0.100	< 0.100	< 0.463
7/12/93		1.790	0.580		< 0.463	< 0.463	0.450	< 0.463			< 0.463	< 0.463	1.700	0.200	< 0.100	< 0.463
7/15/93	3.900		< 0.463	< 0.463	< 0.463	< 0.463						< 0.463	< 0.463	0.130	< 0.100	
7/18/93		< 0.463	< 0.463		1.200	0.770		< 0.463			< 0.463	0.560	< 0.463	< 0.100	< 0.100	< 0.463
7/21/93			0.770			0.690	< 0.463					1.000	0.660	0.230	< 0.100	

μg/m³ - Micrograms per cubic meter
<### - indicates the concentration is less than lower certified reporting limit
FBLK - Field Blank
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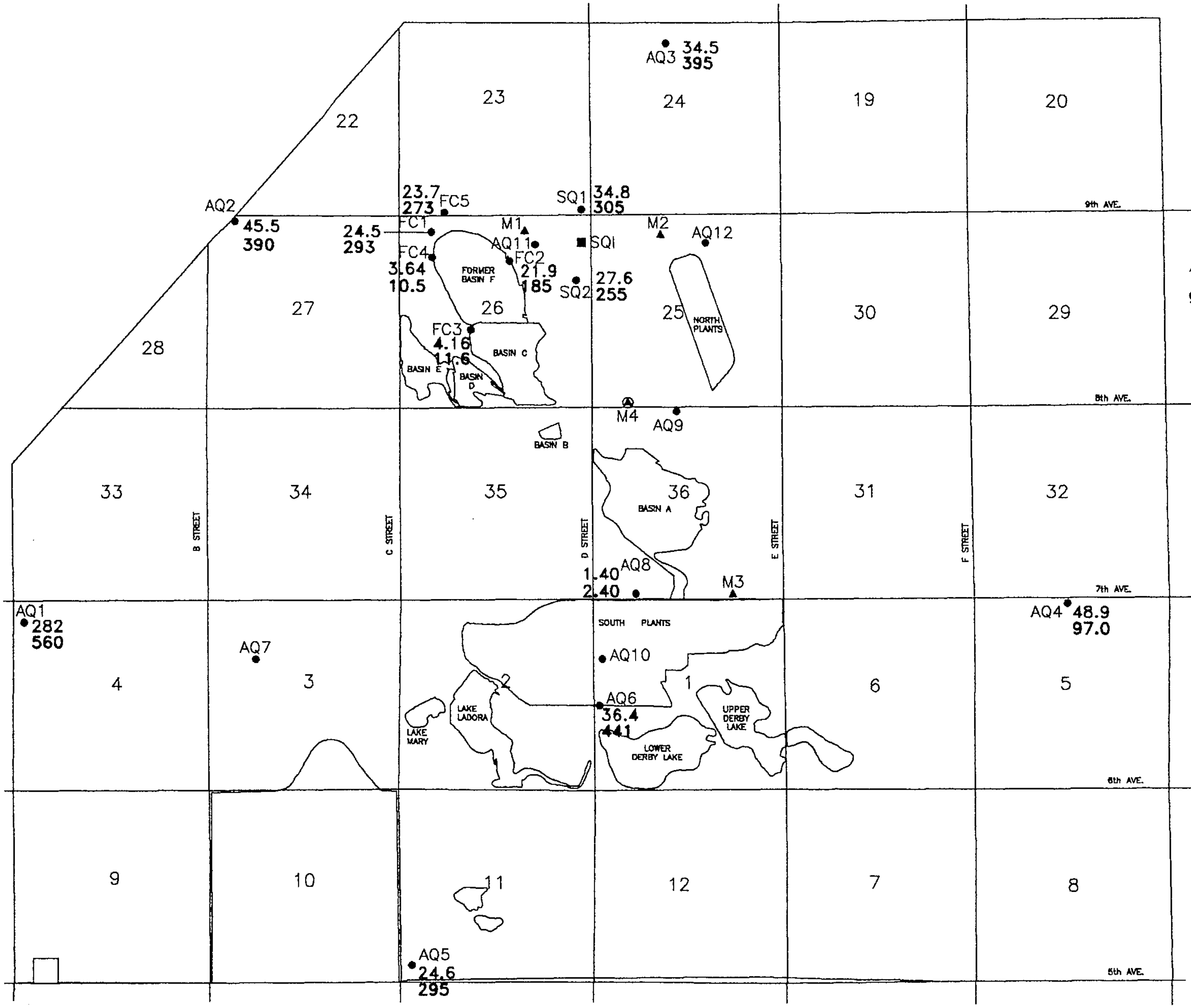
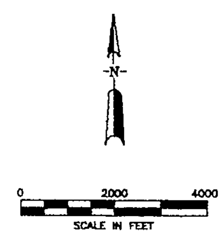


LEGEND

- ● Air Quality Monitoring Station
- ▲ Meteorological Monitoring Station
- Continuous Gaseous and Meteorological Monitoring Station
- ■ Submerged Quench Incinerator

48.9 24 Hr. Average Concentration

97.0 24 Hr. Max. Concentration



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U.S. Army Program Manager
for Rocky Mountain Arsenal

Figure 4.6-9

Methylene Chloride Concentration Results in ug/m³ for the Period 4/16/93 – 7/21/93

Rocky Mountain Arsenal
Prepared by: Ebasco Services Incorporated

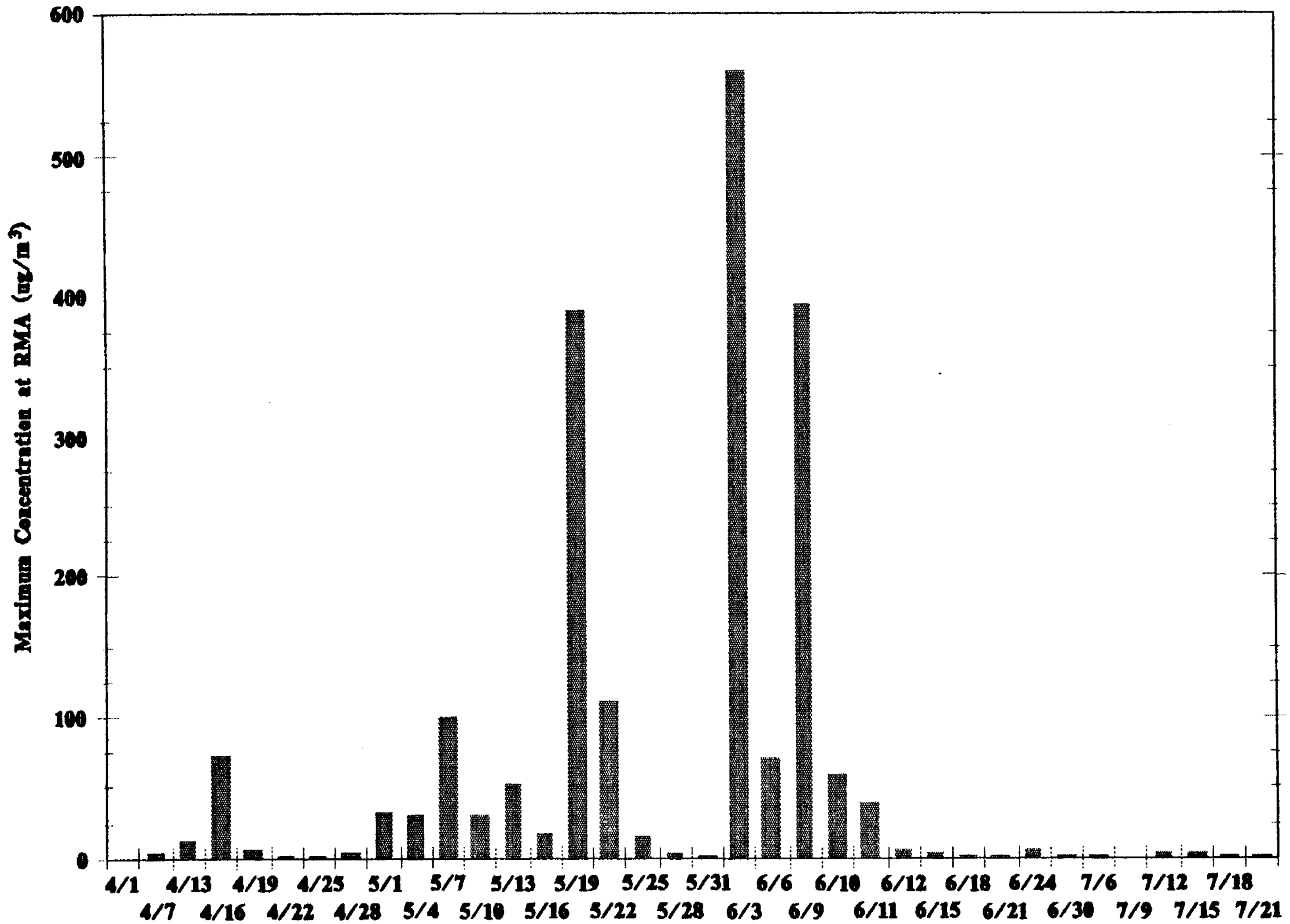

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Figure 4.6-10

Maximum Methylene Chloride Concentrations at RMA

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- Peak concentrations on any given day did not correlate with the dispersion pattern from Basin F, the A-Neck Air Stripper, the SQI or any other potential RMA sources. Several very high concentrations at AQ1, AQ2, AQ4, and AQ5 were outside the wind and dispersion patterns from RMA sources (this will be discussed further).

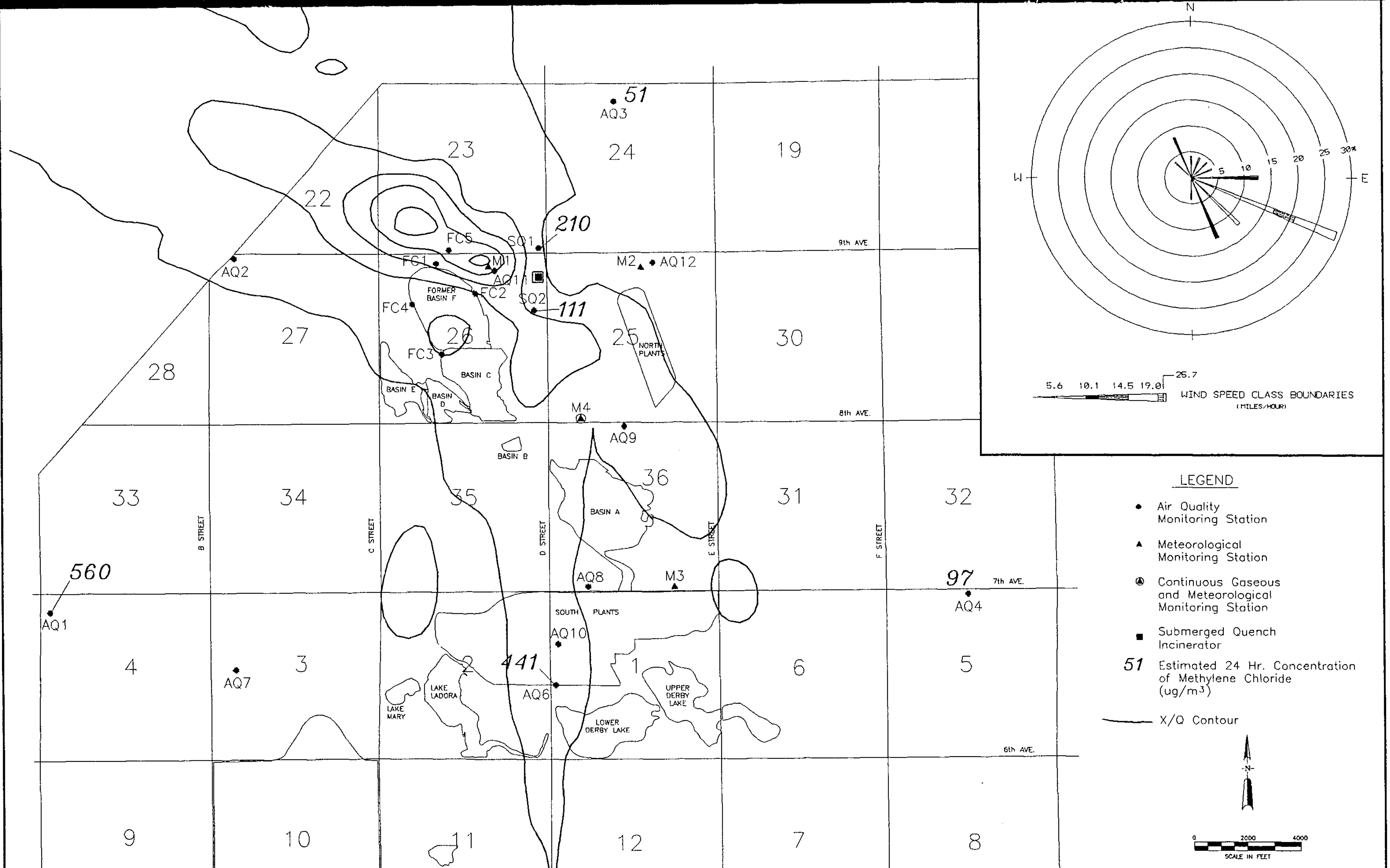
- High methylene chloride concentrations ceased abruptly after July 12 and did not reach a concentration in excess of 5 $\mu g/m^3$ through the remainder of FY93 (higher levels have been experienced in the spring of FY92, and again in the first half of FY94, before this report was completed).

- Methylene chloride was the only parameter that was measured at anomalous levels when compared to the long-term baseline.

4.6.5.2.1 Methylene Chloride Dispersion Assessments

Assuming that the high methylene chloride concentrations resulted from a potential RMA source, a number of modeling scenarios were investigated including Basin F and SQI ground sources and a possible SQI stack source. In no case, however, could a relationship be shown between sampled methylene chloride emissions and a potential RMA source. Two examples are demonstrated below:

1. On June 3, 1993, winds were primarily from the east-southeast, while other directions were infrequently reflected. Figure 4.6-11 shows the wind rose and the dispersion pattern (for the 24-hour period of monitoring) from the SQI stack as a potential source. The principal dispersion impacts are shown to be to the west-northwest of the stack with some lesser impacts to the south. Methylene chloride measurements are shown in Figure 4.6-11 and it is noted that the highest methylene chloride concentration reported was at AQ1 completely outside the dispersion pattern. The second highest concentration (441 $\mu g/m^3$) was at AQ6, which showed a minimal dispersion potential from the SQI stack. AQ4, also removed from the dispersion impact influence, measured a concentration of 97 $\mu g/m^3$. The high concentrations at stations AQ1, AQ5, and AQ4 cannot be explained by the wind and dispersion patterns on this date as coming from any RMA source.



Prepared for:
U.S. Army Program Manager for Rocky Mountain Arsenal

Figure 4.6-11
Estimated Methylene Chloride Concentrations (ug/m³), Wind Rose and X/Q Dispersion Pattern for 6/3/93
Rocky Mountain Arsenal
Prepared by: Ebasco Services Incorporated

2. On May 19, 1993, a similar example can be demonstrated. On this date winds were primarily from the north and north-northeast, with other directions again minimally represented. Figure 4.6-12 shows the winds and dispersion pattern for the period of sampling. The highest concentrations were reported at AQ2 (390 $\mu g/m^3$) and AQ6 (368 $\mu g/m^3$), which were both outside the principal dispersion potential. Stations SQ1, SQ2, AQ3, FC1, FC2, and FC5 all measured moderately high and somewhat uniform methylene chloride concentrations but with no correlation to the dispersion patterns.

Similar disparities between methylene chloride high concentrations, RMA potential emissions, dispersion patterns, and meteorological conditions were observed for the other methylene chloride anomalous concentration days shown in Table 4.6-7.

4.6.5.2.2 Potential Methylene Chloride Sources

The source of methylene chloride as of the date of this report has not been detected. The CAQMMP has continued investigations and analyses to determine if the source is at RMA, but real-time, close-in monitoring of the Basin F waste pile, Pond A, and the storage tanks have indicated no increased levels of methylene chloride emissions. It is noted that there have been no anomalous methylene chloride concentrations measured at RMA in the 5-year post-remedial period, with the exception of the spring of FY92. Other sources of methylene chloride at RMA that could produce ambient concentrations at levels measured during the 3-month sampling period have been surveyed and none identified. The SQI has been ruled out as a possible source of methylene chloride for several reasons:

- High methylene chloride concentrations were noted 12 days prior to the SQI startup operations.
- SQI stack testing during trial burns between May 7 and May 25, 1993 indicated a methylene chloride emission rate of 2.20E-05 g/sec.
- Dispersion modeling indicated that the maximum potential concentrations from the stack using the above emission rate was less than the observed concentrations at downwind receptors by a factor of 10^{-6}.

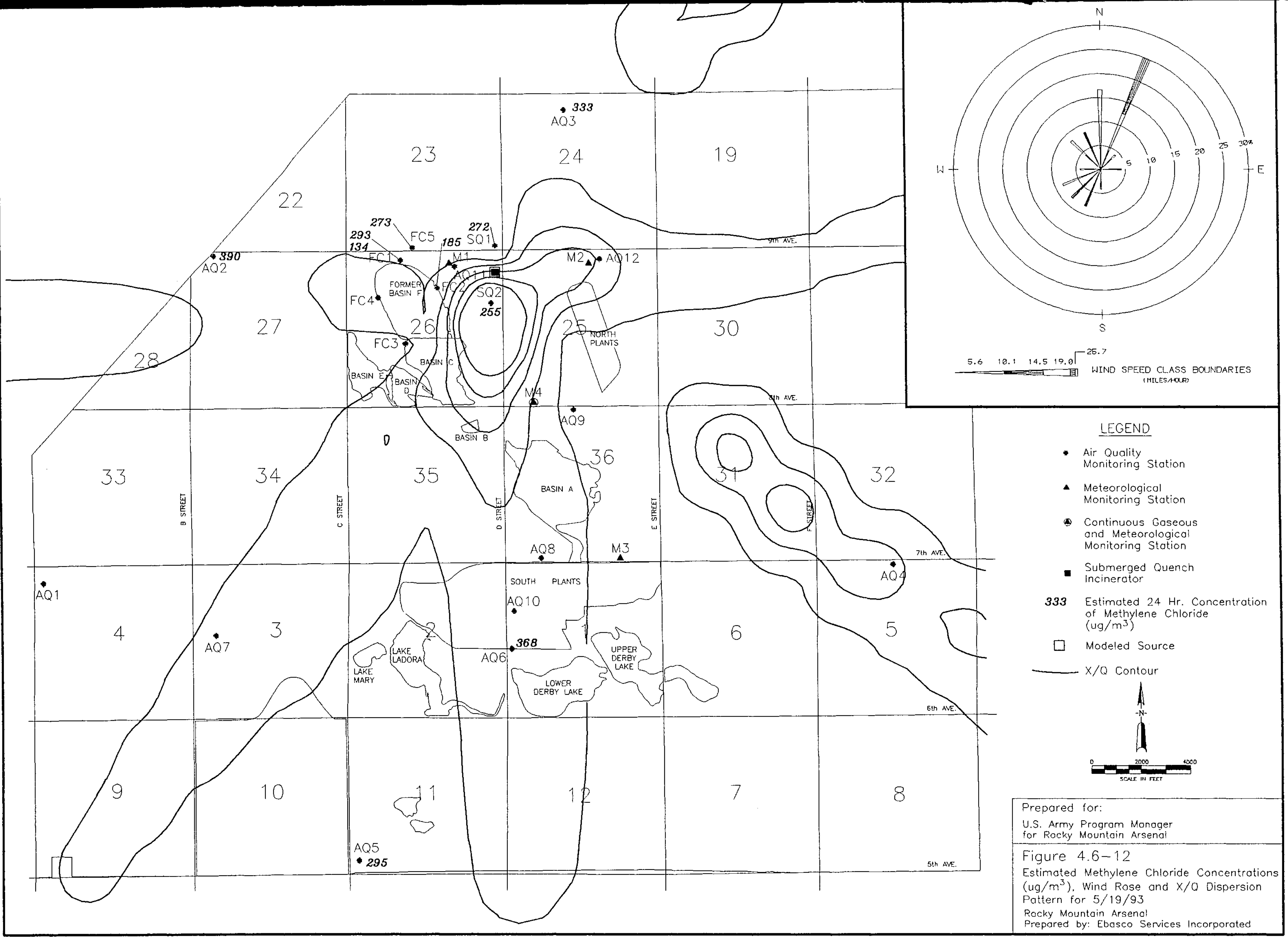


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Figure 4.6–12
Estimated Methylene Chloride Concentrations (ug/m^3), Wind Rose and X/Q Dispersion Pattern for 5/19/93

Rocky Mountain Arsenal
Prepared by: Ebasco Services Incorporated

- The Basin F fluid does not contain methylene chloride at concentrations that, if leaked from piping, could account for observed concentrations at downwind receptors.

- As the Basin F fluid would contain a mixture of other Basin F compounds, these compounds would also be detected in the ambient sample analysis (however, only anomalous levels of methylene chloride were detected).

- Any leaks would result in the dispersion of a low level or ground source, and the highest concentrations would be located close to the tanks at the Basin F and SQI monitoring sites and diminish downwind. In fact, the highest levels were frequently measured at the southern and western perimeter sites (farthest from this potential source).

The CAQMMP investigated the possibility that the high levels of methylene chloride could be a laboratory contamination problem. Laboratory operations were audited and no discrepancies were noted, although methylene chloride has often been considered a laboratory contaminant. It should be noted, however, that there are shortcomings in the CMO4 analytical method for measuring VOCs, as discussed in Section 4.6.8. In addition to breakthroughs of the Tenax and Tenax/charcoal tubes, the concentrations measured were greater than the certified reporting ranges and consequently all concentrations provided in this discussion are "estimated" values so are not certified (estimated levels of methylene chloride have been reported previously in CAQMMP annual reports and the FY93 values are considerably higher).

A distinct possibility exists that the methylene chloride source is off-post. Table 4.6-8 indicates 75 VOC sources in excess of 1 ton per year, that have been identified in the Denver metropolitan area; many of these are clustered close to RMA (see Figure 4.6-13). A number of the VOC sources included methylene chloride, although precise emissions levels have not been officially required for reporting. Such reporting will, in fact, be required in 1994. CAQMMP will continue its investigations in FY94 and update its findings in the next annual report.

4.6.6 Metropolitan Denver Area VOC Emissions

Many of the ambient VOC concentrations measured at RMA interior monitoring stations during FY89, FY90, FY91, FY92, and FY93 were below values measured at Denver metropolitan

Table 4.6-8 Volatile Organic Compound Sources with Emissions greater than 15 Tons Per Year in the RMA Vicinity

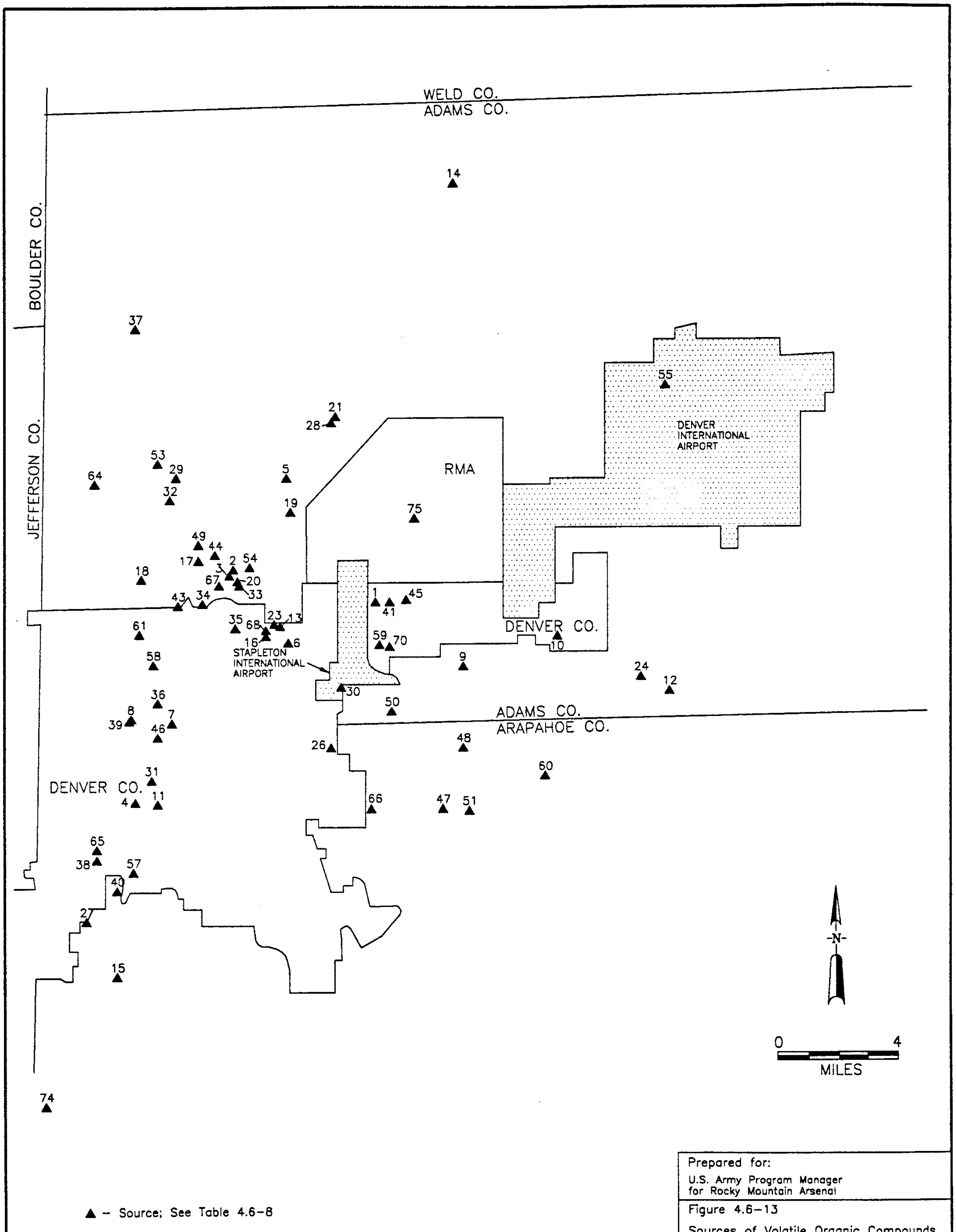
Facility	City	Update Year	Map No.	Estimate (TPY)
Chemical Systems Technology Inc.	Denver	90	1	6655.0
Colorado Refining Company / Total Petroleum	Commerce City	91	2	988.6
Conoco Inc. - Denver Refinery	Commerce City	91	3	739.8
Denver Industrial Sales & Service	Denver	90	4	256.7
Wyco Pipe Line Company Dupont Terminal	Dupont	92	5	236.3
Pillow Kingdom Mfg	Denver	91	6	213.0
Swedish Medical Center	Englewood	91	7	155.2
Union Chemicals Division Union Oil of Ca	Denver	92	8	143.0
Chase Terminal Co.	Aurora	92	9	120.5
Mastercraft	Aurora	92	10	120.0
The Gates Rubber Co.	Denver	90	11	117.7
Amoco Production Co. - Wattenberg Plant	Watkins	92	12	115.8
Schafer Commercial Seating Inc.	Denver	92	13	100.0
Central Products Co.	Brighton	91	14	94.2
The Electron Corporation	Littleton	91	15	87.2
Pillow Kingdom Mfg	Denver	91	16	73.0
Public Service Company - Cherokee	Denver	91	17	71.8
Atlas/Judds Brothers	Denver	89	18	69.9
Rainbo Bread Co	Commerce City	92	19	65.0
Diamond Shamrock Inc.	Commerce City	91	20	62.1
Sinclair Oil Denver Products Terminal	Henderson	92	21	59.2
Advance Foam Plastics Inc	Denver	92	22	58.1
Energy Thermal Systems Inc.	Denver	90	23	55.6
Colorado Interstate Gas Co - Watkins Station	Watkins	91	24	55.0
Accurate Plastics	Longmont	92	25	49.0
Lowry Air Force Base	Denver	90	26	44.8
Modern Plastics Inc.	Englewood	91	27	42.8
Emc-Henderson Terminal	Henderson	92	28	42.0
W.J. Whatley, Inc	Commerce City	92	29	41.7
E/M Corporation 12555 E. 37th Ave.	No city name	90	30	37.0
Pharmaceutical Basics, Inc	Denver	91	31	35.6
Hughes and Company	Commerce City	90	32	33.6
Phillips Pipeline Co	Commerce City	91	33	33.2
Power Assist Co. Inc.	Denver	90	34	33.1
The Denver Post Corp	Denver	92	35	31.0
Quik Print of Denver	Denver	90	36	30.5
AT&T Info. Systems	Westminster	90	37	30.1
Import Auto Body	Denver	90	38	30.0

Source: CDH 1993

Table 4.6-8 Volatile Organic Compound Sources with Emissions greater than 15 Tons Per Year in the RMA Vicinity

Facility	City	Update Year	Map No.	Estimate (TPY)
Cohler-Mclister	Denver	90	39	29.2
Sterling Stainless Tube Corp	Englewood	88	40	29.0
Pease Industries Inc Montbello Ind Park	Denver	90	41	27.8
Styro-Molders	Aurora	92	42	27.6
Ardco Corporation	Denver	92	43	27.4
Metro Wastewater Reclamation District	Denver	91	44	25.4
Conoco Inc. S. Federal Blvd.	No city name	89	45	24.9
Conoco 8073 S. Broadway Littleton	Littleton	90	46	24.9
Phillips 66 Co 13780 E 6th Ave Aurora	Aurora	90	47	23.7
Phillips 66-14401 E. Colfax Ave.,Aurora	Westminster	90	48	23.7
Phillips 66	Arvada	92	49	23.3
Silver State Cleaners	Denver	92	50	22.0
Amoco Gas Station #3691	Aurora	92	51	21.1
Phoenix Press	Denver	91	52	21.0
Phillips 66	Broomfield	92	53	19.4
United Asphalts Inc 4306 East 60th	No city name	90	54	19.1
Koch Hydrocarbon Co. Third Creek Plant	Brighton	92	55	18.0
Total Petroleum, Inc. #2498	Denver	92	56	17.9
Public Service Company - Arapahoe	Denver	91	57	17.4
B-D Chemical Co. Inc.	Denver	90	58	17.2
Kwal Paints Inc.	Denver	90	59	17.2
Buckley ANG Base - Colo. Air Nat'l Guard	Aurora	91	60	17.2
Brannan S & G	Denver	90	61	17.0
Total Petroleum Inc. #2344	Westminster	91	62	17.0
Total Petroleum Inc. #2355	Denver	91	63	16.7
Exxon Corporation-7995 N Federal Blvd	Westminster	90	64	16.6
Exxon Corp 2110 S Federal Denver	Denver	90	65	16.5
Exxon Corp 1090 S Havana St Aurora	Aurora	90	66	16.5
Republic Paperboard Company	Commerce City	92	67	16.5
Stemco Manufacturing	Denver	92	68	16.4
Denver Forms	No city name	91	69	16.0
Frito Lay Inc.	Denver	89	70	15.9
Total Petroleum, Inc. #2463	Littleton	91	71	15.4
Total Petroleum Inc. #2348	Denver	91	72	15.2
Total Petroleum Inc. #2337	Denver	91	73	15.1
T.A. Pelsue	No city name	90	74	15.0
Rocky Mountain Arsenal	Commerce City	92	75	1.1

Source: CDH 1993



Prepared for:
U.S. Army Program Manager for Rocky Mountain Arsenal

Figure 4.6–13

Sources of Volatile Organic Compounds in the RMA Vicinity (Reported Emissions >15 tons per year)

Rocky Mountain Arsenal
Prepared by: Ebasco Services Incorporated

stations during various studies (See Tables 4.6-14 and 4.6-15 in the FY91 CMP Annual Assessment Report, and Tables 4.6-11 and 4.6-12 in this report). Measured ambient concentrations of various VOC analytes that were elevated during Basin F remediation activities decreased to typical urban background levels during the post-remedial monitoring periods, and have continued to occur at these levels during FY93. Some ambient VOC concentrations measured at the RMA monitoring sites during FY93 continued to be influenced by residual emissions from Basin F and from undisturbed areas of the South Plants and Basin A (as in previous post-remedial monitoring periods). However, many of the temporal differences in measured ambient VOC concentrations at CAQMMP sampling sites appeared to result from varying meteorological conditions that affected on-site transport of background emissions not located on RMA.

Table 4.6-8 and Figure 4.6-13 present numerous VOC point sources identified by CDH that may impact air quality monitored within RMA (CDH 1993). Emission sources included in this list were those exceeding 15 tpy of VOCs and represent approximately 80 percent of all VOC emissions identified in Adams, Arapahoe, and Denver counties. This list of sources included several major industries (Chemical Systems Technology, Inc., Colorado Refining Company, Conoco Denver Refinery, Sinclair Pipeline Company, Pillow Kingdom, Wyco Pipeline Company, Continental Airlines, and Gates Rubber Company) and numerous smaller industrial operations, chemical plants, paint manufacturing facilities, and large gasoline service stations. In addition, there are many VOC point sources below 10 tpy in the metropolitan Denver area that include dry cleaning establishments, paint stores, automobile maintenance shops, and small service stations. Background VOC emissions also originate from mobile sources including gasoline- and diesel-burning vehicles, construction equipment, and aircraft operating from nearby Stapleton International Airport (and the soon-to-be operational Denver International Airport), and are likely a significant portion of the total VOCs present in the metropolitan area. Another source of VOC emissions not readily quantifiable for documentation in an emissions inventory is from feedlot facilities located north of RMA.

Table 4.6-9 classifies releases of Denver area VOC sources by specific toxicity criteria according to health-related characteristics (Citizens Fund 1992). The release quantities are expressed in terms of total pounds of air, water, and any other release medium at a particular facility. The relative toxicity of each VOC release cannot be evaluated strictly by emissions quantity; other factors that need to be considered include chemical reactivity in the ambient air and the relative toxicity hazard of each VOC.

Specific VOC releases from metropolitan Denver emission sources are likely to have contributed to observed ambient VOC concentrations at the RMA air monitoring sites. Several of the major sources are within 2 miles of the RMA boundary such as Colorado Refining Company, Conoco Refinery, Sinclair Pipeline Company, Pillow Kingdom, Wyco Pipeline Company, and Continental Airlines. The number, the diversity of emissions, and the geographical extent of the emission sources complicates the attribution of specific off-site emission sources to observed VOC concentrations at specific RMA monitoring sites. As noted in various examples provided in this report, a number of observed maximum VOC concentrations at the RMA perimeter monitoring sites occurred concurrently with prevailing wind flow from potential off-site emission sources in the direction of the RMA monitoring sites. High-event monitoring during FY93 resulted in observed ambient concentrations of certain VOC analytes that were highest at perimeter sites AQ1, AQ2, AQ3, AQ4, and AQ5. The December 8, 1992 intense inversion episode, however, resulted in the pervasive influence of various VOC constituents across all of the RMA sampling sites, as was the possible incursions of methylene chloride during the late spring of FY93. As the CAQMMP continues to monitor on-going and future remediation activities, a continuing effort will be made to identify point and area sources both on and off post.

4.6.7 Summary of VOC Results

Table 4.6-10 summarizes maximum average and maximum 24-hour concentrations throughout the CMP/CAQMMP program history. The State of Colorado has not published air toxics regulations or promulgated standards. Promulgated state air toxics standards are not anticipated until amendments to Section 112 of the Clean Air Act are finalized in 1996.

Table 4.6-9 Total Pounds of Releases of Toxic Chemicals, 1990 by Facility and Toxicity for Denver and Adams Counties

Facility	Zip	Carcinogen	Heritable Mutagen	Developmental Toxin	Reproductive Toxin	Acute Toxin	Chronic Toxin	Neuro-Toxin
A.B. Hirschfield Press, Inc.	80216	0	0	17,236	17,236	0	17,236	0
A.R. Wifley & Sons Inc.	80205	10	0	5	5	0	10	0
Aaa Plating Inc.	80205	0	0	0	0	750	750	0
Altac Corp.	80601	0	0	114,297	114,297	0	0	0
Asarco Inc. Globe Plant	80216	0	0	0	0	751	751	0
Atlas Energy Products	80229	0	0	0	0	0	0	0
Boyles Galvanizing Co.	80222	0	0	0	0	60,403	60,403	0
Bryant Electric Inc.	80216	250	0	0	0	0	250	0
Cai Technologies	80204	0	0	0	0	505	0	0
Chemical & Metal Industries, Inc.	80216	59,819	0	59,819	76,897	13,298	47,531	0
Chemical Systems Technology Inc.	80239	0	0	0	0	0	0	0
Chemrex Inc.	80022	6,960	0	0	0	0	0	0
Cobitco Inc.	80216	0	0	0	0	95	95	0
Coca-Cola Bottling Co.	80205	0	0	0	0	0	0	0
Colorado Paint Co.	80216	0	0	1,500	1,500	0	1,010	500
Colorado Refining Co.	80022	10,155	0	24,275	19,255	4,026	20,321	0
Conoco Denver Refinery	80022	3,753	0	33,602	33,602	370	37,496	3,727
Continental Airlines Base Maintenance	80207	3,046	0	11,156	11,156	0	645,271	0
Cryenco	80229	0	0	21,100	21,100	0	0	0
Delta Rocky Mountain Petroleum	80640	0	0	0	0	0	10	0
Denver Metal Finishing	80216	0	0	9,865	9,865	0	0	0
Dow Chemical Co.	80010	0	0	0	0	0	0	2

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Table 4.6-9 Total Pounds of Releases of Toxic Chemicals, 1990 by Facility and Toxicity for Denver and Adams Counties

Facility	Zip	Carcinogen	Heritable Mutagen	Developmental Toxin	Reproductive Toxin	Acute Toxin	Chronic Toxin	Neuro-Toxin
DPC Industries Inc.	80022	0	0	0	0	3,414	3,414	0
Eaton Metal Products Co. Inc.	80216	0	0	0	0	0	0	0
Electromedics Inc.	80112	17,502	17,502	17,502	17,502	17,502	190,490	0
Electron Corp.	80120	0	0	1,030	1,030	0	0	3,139
Firestone Building Products	80216	0	0	0	0	0	5	0
Jackson Ice Cream Co.	80204	0	0	0	0	5,500	5,500	0
Koppers Industries Inc.	80216	229,650	0	60	60	0	60	0
Kwal-Howells Inc.	80239	0	0	0	0	0	750	0
Lakewood Brick & Tile Co.	80214	0	0	0	0	0	0	0
Majestic Metals Inc.	80229	0	0	11,900	11,900	0	11,900	0
Martin Marietta Astronautics	80127	0	0	153,270	153,270	500	79,600	40,600
Medtronic Hemotec Inc.	80112	0	0	0	0	0	7,510	0
Meas Fiberglass Inc.	80022	5,840	5,840	0	0	0	5,840	0
Metal Treating & Research Co.	80229	0	0	0	0	0	0	500
Metrum Information Storage	80122	0	0	11,811	11,811	0	18,213	0
Mid-America Plating Inc.	80216	0	0	0	0	32	21	0
Mile High Equipment Co.	80239	0	0	250	250	64,500	64,500	0
Modine Western-Rocky Mountain	80223	0	0	109	109	0	0	0
Ner Data Products Inc.	80216	0	0	5,389	5,389	0	0	0
Norgren Co.	80120	0	0	0	0	5	5	0
Pease Industries Inc.	80239	0	0	109,000	109,000	0	76,000	76,000
Pepsi-Cola Bottling Co.	80216	0	0	0	0	0	0	0

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Table 4.6-9 Total Pounds of Releases of Toxic Chemicals, 1990 by Facility and Toxicity for Denver and Adams Counties

Facility	Zip	Carcinogen	Heritable Mutagen	Developmental Toxin	Reproductive Toxin	Acute Toxin	Chronic Toxin	Neuro-Toxin
Protecto Wrap Co.	80223	0	0	997	997	0	10	5
Purina Mills Inc.	80640	0	0	0	0	0	0	0
Redfield Riflescopes Inc.	80224	0	0	32,700	32,700	0	0	0
RMO Inc.	80204	0	0	0	0	4	4	0
Safeway Milk Plant	80216	0	0	0	0	0	0	0
Sampsonite Corp.	80239	0	0	145,389	145,389	0	0	0
Sas Circuits Inc.	80127	0	0	0	0	500	500	0
Sashco Inc.	80022	0	0	250	250	0	0	0
Sashco Inc.	80223	0	0	0	0	0	1,000	0
Scott's Liquid Gold Inc.	80239	0	0	4,251	4,251	0	0	0
Shafer Commercial Seating Inc.	80216	350	350	44,341	44,655	36	48,515	21,656
Silver Engineering Works Inc.	80011	438	0	249	249	0	438	0
Stanley Aviation Corp.	80010	40,347	0	71,334	71,334	0	40,347	0
Thompson Pipe & Steel Co.	80216	0	0	0	0	0	0	250
W.J. Whatley Inc.	80022	2,400	2,400	0	0	0	42,871	0
Whirlpool Kitchens Inc.	80011	0	0	64,665	64,665	0	12,766	0
Whitaker Power Storage Systems	80207	0	0	0	0	215	215	0
Wright & Megill Co.	80216	30	0	30	30	40	70	0
Zimmerman Metals Inc.	80216	2,805	0	5	5	0	2,805	250

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Table 4.6-10 Maximum Concentrations and Locations of Volatile Organic Compounds During CAQMMP, CMP, Basin F, and IRA-F Programs

VOC	Maximum Long-Term Average (μg/m³)	Location	Phase	Maximum 24-Hour Concentration (μg/m³)	Location	Phase
1,1,1-Trichloroethane	10.53	BF4	P1	72.54	BF1	P1
1,1,2-Trichloroethane	0.46	BF2	P2-S2	4.00	BF2	P2-S2
1,1-Dichloroethane	0.14	CMP/BF3	P1	0.27	CMP/BF3	P1
Trans-1,2-Dichloroethene	0.02	BF7	P2-S1	0.20	SQ2	P7
1,2-Dichloroethane	0.49	AQ5	P2-S2	3.80	RIFS2	P2-S1
Bicycloheptadiene	9.96	BF2	P1	39.46	BF2	P1
Benzene	10.53	CMP/BF1	P1	44.29	CMP/BF1	P1
Carbon Tetrachloride	1.99	RIFS2	P2-S1	9.76	RIFS2	P1
Methylene Chloride	24.01	AQ5	P3	560.00	AQ1	P7
Chloroform	6.95	BF2	P1	37.15	BF2	P2-S2
Chlorobenzene	0.47	CMP/BF2	P1	2.53	CMP/BF2	P1
Dibromochloropropane	2.90	CMP/BF2	P1	17.04	CMP/BF2	P1
Dicyclopentadiene	4.53	BF2	P1	29.12	BF2	P1
Dimethyldisulfide	7.86	BF1	P1	36.72	BF1	P1
Ethylbenzene	2.39	CMP/BF2	P1	14.12	SQ1	P7
Toluene	23.55	BF2	P1	158.04	BF2	P1
Methyl isobutyl ketone	0.47	AQ6	P3	1.13	FC4	P4
Tetrachloroethane	5.29	BF1	P2-S2	24.02	BF1	P2-S2
Trichloroethene	6.98	BF1	P2-S2	40.43	BF1	P2-S2
Xylenes	8.57	BF2	P1	51.39	SQ1	P7

Note: Data from both within and above the certified range are summarized here. Long-term refers to averages by phase.

P1 = Phase 1, is from March 22 to December 12, 1988.
P2-S1 = Phase 2, Stage 1, is from December 13, 1988 to February 15, 1989.
P2-S2 = Phase 2, Stage 2, is from February 16, 1989 to May 5, 1989.
P3 = Phase 3, is from May 6, 1989 to September 30, 1989.
P4 = Phase 4, is from October 1, 1989 to September 30, 1990.
P5 = Phase 5, is from October 1, 1990 to September 30, 1991.
P6 = Phase 6, is from October 1, 1991 to September 30, 1992.
P7 = Phase 7, is from October 1, 1992 to September 30, 1993.

μg/m³ Microgram per cubic meter

4.6.7.1 Other Comparisons

EPA conducted an air toxic study in the Denver area during the summer of 1987 and the winter of 1987-1988 (EPA 1989b). This study was discussed in the CMP FY89 Contamination Assessment Report and a comparison was made between maximum VOC concentrations measured in the Denver study and those measured at RMA (RLSA 1990b). An update of the RMA results is provided in Table 4.6-11 (last column). It is also anticipated that with recent CDH and EPA emphasis on toxic organic compounds, an update of the Denver data will be shortly forthcoming.

Where toxic guidelines vary significantly, perhaps a more meaningful evaluation would be a comparison of the RMA-measured VOC compounds with those of typical urban VOC levels. Table 4.6-12 compares the CAQMMP VOC results for FY93 to published EPA studies for both the Denver metropolitan area and a summary of "air toxic" results from studies across the country. CAQMMP concentrations were generally found to be less than the concentrations reported by the EPA urban airshed studies. Nevertheless, while the average maximum levels of compounds identified as concerns at the RMA boundaries, and other compounds identified as potential source emissions from Basin F, were equivalent to or below Denver and other urban source levels, the intent of this assessment is not to suggest that some potentially toxic air compounds may not have been emitted from various RMA sources and remedial activities. Analysis of results again suggests continued monitoring of these compounds with additional emphasis placed on identifying specific RMA local sources from new remediation activities, as well as delineating these from regional emission sources. Concentrations of some compounds may be the result of previous RMA production activities; others are typical industrial and traffic related compounds and are released throughout the Denver urban metropolitan area. RMA VOC measurements need to be evaluated quantitatively in terms of both internal and external sources. The CAQMMP will continue to address this issue.

Table 4.6-11 Comparison of EPA Air Toxic Study and Rocky Mountain Arsenal Results for Volatile Organic Compounds

Analyte	Maximum Concentration for Denver Study* ($\mu g/m^3$)	Maximum Concentration at RMA ($\mu g/m^3$) (Phases 1-3)	Maximum Concentration at RMA ($\mu g/m^3$) (Phase 4)	Maximum Concentration at RMA ($\mu g/m^3$) (Phase 5)	Maximum Concentration at RMA ($\mu g/m^3$) (Phase 6)	Maximum Concentration at RMA ($\mu g/m^3$) (Phase 7)
1,2-Dichloroethane	49	4	0.2	0.2	0.8	0.3
1,1,1-Trichloroethane	44	73	7.2	5.8	5.1	20
Carbon Tetrachloride	3	10	1.9	1.8	1.3	5.4
Trichloroethene	4	40	0.5	0.2	0.7	0.7
Tetrachloroethene	14	24	6.3	2.3	2.8	17
Benzene	83	44	7.5	9.1	5.4	34
Toluene	294	158	16.9	10.8	5.9	88
Ethylbenzene	22	13	5.3	2.2	2.6	14
o-Xylene	13	8	5.9	--	--	--
m- and p-Xylene (Total Xylenes)	252	50	9.5	10.1	14.2	51
Chlorobenzene	83	3	0.1	0.1	0.1	0.1

* Source: U.S. EPA. 1989. Report on the Air Toxics Monitoring Program for the Denver Metropolitan Area. Integrated Environmental Management Project. Report One, Data Summary. Region VIII, Denver, Colorado

-- Not analyzed during this phase
$\mu g/m^3$ Micrograms per cubic meter

Phase 1-3 March 22, 1988 to September 30, 1989.
Phase 4 October 1, 1989 to September 30, 1990.
Phase 5 October 1, 1990 to September 30, 1991.
Phase 6 October 1, 1991 to September 30, 1992.
Phase 7 October 1, 1992 to September 30, 1993.

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Table 4.6-12 Ambient Volatile Organic Compound Concentrations from Various Studies

Target Name	1987 EPA NMOC Study Means μg/m³	1988 EPA UATMP Mean μg/m³	FY93 CMP* Basin F (FC-2) Mean μg/m³	FY93 CMP* interior (AQ6) Mean μg/m³	FY 93 CMP* Perimeter (AQ2) Mean μg/m³
1,1,1-Trichloroethane	18.6	6.7	1.892	1.771	1.954
1,1,2-Trichloroethane	--	3.0	0.084	0.084	0.084
1,1-Dichloroethane	13.7	2.0	0.028	0.028	0.028
1,2-Dichloroethane	25.1	8.1	0.040	0.037	0.039
Benzene	6.5	5.2	2.851	2.070	3.178
Bicycloheptadiene	--	--	0.085	0.028	0.028
Carbon Tetrachloride	--	2.1	0.743	0.656	0.758
Chlorobenzene	7.4	3.0	0.030	0.030	0.030
Chloroform	--	30.8	1.755	0.304	0.585
Dicyclopentiadiene	--	--	0.206	0.206	0.206
Dimethyldisulfide	--	--	0.114	0.114	0.114
Ethylbenzene	--	7.0	0.639	0.487	0.774
Methylene Chloride	78.4	18.1	7.667	18.036	14.178
Methylisobutyl Ketone	--	--	0.370	0.370	0.370
m-Xylene	59.1	18.7	--	--	--
N-Nitrosodimethylamine	--	--	--	--	--
o-Xylene (12DBM)	7.4	5.7	--	--	--
p-Xylene	59.1	18.9	3.087+	2.334+	3.712+
Tetrachloroethylene	34.1	13.1	0.640	0.436	0.645
Toluene	32.0	16.4	4.776	4.020	5.980
Trans-1,2-Dichloroethylene	9.7	4.4	--	--	--
Trichloroethylene	20.8	10.4	0.044	0.035	0.043

Source: U.S. EPA, 1988. 1987 Nonmethane Organic Compound and Air Toxics Monitoring Program, Final Report, Vol II, "Toxic Species." EPA-450/4-88-012. Research Triangle Pack, North Carolina: U.S. EPA Office of Research and Development.

* Data from both within and above the certified range are reported here.

Legend: NMOC = Non methane Organic Compound
UATMP = Urban Air Toxics Monitoring Program
CMP = Comprehensive Monitoring Program

-- Not analyzed during this phase
\+ Monitoring result based on total xylenes
μg/m³ Micrograms per cubic meter

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In general, compounds at RMA did not appear to present toxic health risks significantly different from the urban environment of metropolitan Denver. Organic compounds that were unique to Basin F and other remediation areas decreased rapidly with distance from these sources and were at lower levels at the RMA boundaries.

4.6.8 VOC Performance Evaluation

In response to the PMRMA Laboratory Support Division (LSD) request, a review of information pertaining to sampling and analysis of VOCs was carried out under the CAQMMP in order to evaluate the performance characteristics of currently utilized methods and to examine potential alternatives for any appropriate improvements. A report on this evaluation was submitted to LSD in May 1993. This section presents a general discussion of performance evaluation observations, an examination of collected data and potential adjustments, and the applicability of alternative methods.

4.6.8.1 Background Information

USATHAMA method CM04 is presently used to analyze VOCs sampled in ambient air. The method has undergone several changes in the course of the CMP and the follow-on CAQMMP at RMA. For example, prior to January 1991 VOCs were analyzed using Midwest Research Institute's (MRI) Method E-7, which employed a glass cartridge instead of the longer stainless steel cartridge currently used. A backup cartridge packed with both Tenax and activated carbon was also utilized by MRI. During the original CMP, the front and back cartridge concentrations were reported as a total concentration for the sample.

Another feature of the initial analysis procedure was that when sample measurements were above the CRL, concentrations were estimated by extrapolating the concentration curve above the certified range. Such results represented a "best estimate" of the measured concentration; the data were not certified in accordance with PMRMA/USATHAMA standards, but were reported as estimates in the CMP Annual Reports (1988, 1989, 1990, 1991) indicating maximum

concentrations. This procedure of estimating was useful in augmenting the long-term data record for baseline and remedial progress documentation.

Starting in January 1991, the Environmental Science and Engineering (ESE) laboratory introduced a new design for the Tenax and Tenax/carbon sampling cartridges. Stainless steel tubing, with approximately the same diameter but greater length than previously employed by MRI, was packed with approximately 3.5 grams of Tenax, which was a greater amount than that used in the glass cartridges; a back tube was also used and packed with Tenax and activated carbon. MRI's front cartridges were packed with 1.6 grams of Tenax; their back cartridges were packed with 1.0 gram of Tenax and 1.0 gram of activated carbon (approximate amounts). Along with the cartridge changes, the analytical procedure also changed. ESE's written method, CM04, stated that the front cartridge would be analyzed and approximately 10 to 20 percent of the back cartridges would be analyzed to maintain quality control and to account for any breakthrough of target analytes from the front to the back cartridge. If the back cartridge contained more than 15 percent of the weight detected on the front cartridge, another back cartridge from the same lot was to be analyzed.

ESE analyzed nearly 20 percent of the back cartridges for the FY91 air program. When analyzed, the detections from the back cartridge were automatically added to the front cartridges and reported as one concentration. (In FY93, because of the frequent occurrence of "breakthroughs", LSD required that the laboratory analyze <u>all</u> backup cartridges.)

While many of the target analytes were not seen as back tube detections, several back tube detections including 1,1,1-trichloroethane, benzene, carbon tetrachloride, and chloroform, were reported in excess of 30 percent. Also, many of the back cartridge detections were over the 15 percent breakthrough level indicator (20 percent is currently considered as the appropriate indicator) suggesting that significant breakthrough of these compounds was taking place. Consequently, the FY91 Report stated that VOC concentrations listed in the Installation

Restoration Data Management Information System (IRDMIS) were suspected to be low for certain compounds.

During the latter half of 1991, the CMP operator changed the flow rate from 200 standard cubic centimeters per minute (sccm, ref. 25°C, 760 mm Hg) to 150 sccm. A report provided by ESE (July 1992) confirmed the effectiveness of reducing breakthrough by decreasing the flow rate.

In response to PMRMA/LSD's request for evaluation of the performance characteristics of the current VOC sampling and analysis methods (and to examine potential alternative methods), the next approach was to evaluate the latest VOC data available from the laboratory (October 1992 to January 1993). These were then compared with the last set of data provided under ESE laboratory analysis (FY91). Results again confirmed the effectiveness of decreasing breakthrough by reducing flow rates, but also indicated an increase in "greater than" (above CRL) measurements, as well as an increased frequency of concentrations below the detection limits for certain analytes. Key findings were as follows:

(1) With respect to breakthrough, improvements were obtained as a result of decreasing the target volume from flowrates of 200 sccm to 150 sccm. This improvement was especially noticeable for benzene, 1,2-dichloroethane, trans-1,2-dichloroethene, and total xylenes. Of the certified analytes, carbon tetrachloride, chloroform, and 1,1,1-trichloroethane continued to exhibit breakthrough levels greater than 20 percent at frequencies of 16 percent or greater. In the transition to the reduced sample volume, breakthrough levels and frequency of breakthrough occurrence also increased substantially for methylene chloride, which is reported as a non-certified analyte.

(2) Following reduction of the target sample volume, exceedence of the upper CRL occurred <u>more</u> frequently for certain analytes. Compounds exhibiting the greatest incidence of CRL exceedence included benzene, toluene, 1,1,1-trichloroethane, and total xylenes. The increased frequency of CRL exceedence for these compounds may be associated with

improved collection performance on the front Tenax cartridge as a result of the lowered sampling volume.

(3) There are a large number of variables involved in selecting the most appropriate method for VOC analysis. The technical analysis provided to RMA concerning possible changes and improvements to the existing CMO4 method indicated that an alternative VOC analysis method must consider factors such as method reliability, consistency with past remedial progress data, practicality, economics, application of the latest state-of-the-art techniques, and most important, the objectives of the CAQMMP. These considerations are discussed below.

4.6.8.2 Pertinent Technical Guidance Factors

Guidance for sampling VOCs with Tenax-GC is given in Method TO-1 of the EPA Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air. Method TO-1 indicates that, for the purpose of general guidance, breakthrough levels of <u>less than 20 percent are acceptable.</u> According to Method IP-1B in the EPA Compendium of Methods for the Determination of Air Pollutants in Indoor Air, which pertains to sampling VOCs with Tenax, temperature is often the major factor influencing breakthrough volumes for an analyte when its ambient concentration is less than 100 ppm. Given that the typical ambient concentration of VOCs at RMA is less than 100 ppm, temperature and sample volume will chiefly dictate the point at which breakthrough would occur.

A complicating factor in assessing actual breakthrough levels in the CM04 method is the presence of a dissimilar adsorbent in the back cartridge. The carbon packing in the backup cartridge broadens the potential for increased adsorption of very volatile compounds such as chloroform and 1,1,1-trichloroethane in that section. As such, the determination of breakthrough performance of the VOC sample cartridge sets is not totally straightforward for some of the highly volatile compounds that would have low breakthrough volumes with Tenax and high breakthrough volume with activated carbon.

Methods TO-1 and IP-1B provide estimated breakthrough volumes at 100°F for many of the analytes in the CM04 list. The methods state that the estimated breakthrough volumes may be used as a rough guidance and should probably be reduced by a certain factor to accommodate their approximate accuracy. For the purposes of this review, "safe" sampling volumes for each compound were calculated from the TO-1 and IP-1B suggested volumes using a reduction factor of 33 percent and incorporated a front cartridge and sorbent weight of 4 grams. Based on these calculations, it appeared that the "safe" sampling volumes of several of the volatile halogenated organics in the CM04 analyte list are less than the present sampling volume.

Additional factors to be considered in the use of solid adsorbents for VOC sampling are the potential formation of artifacts under certain conditions and the importance of analyte polarity. As indicated in Method CM04, the presence of oxidants in the sample atmosphere can produce artifacts through reactions with the organics adsorbed on Tenax-GC. Activated carbon is also cited in the EPA compendiums as being prone to artifact formation. This effect may result in the formation of detectable levels of compounds that were not originally present in the ambient air. A complete evaluation of artifact effects and their significance in this program would necessitate further detailed review. However, it is not apparent at this time that artifact formation has been significant in the analytical results. Method TO-1 is described as being applicable to nonpolar compounds. Adsorbent collection and adsorption efficiencies and analytical performance may be affected to varying degrees by the polarity of an analyte. When using the TO-1 or CM04 types of methodologies, nonpolar compounds are generally considered to be less problematic than polar compounds with respect to sampling and analysis performance. Most of the compounds in the CM04 method have nonpolar characteristics with respect to the sampling and analysis approaches, with the exception of methyl isobutyl ketone, and perhaps dicyclopentadiene and bicycloheptadiene.

4.6.8.3 Potential CM04 Method Adjustments and Alternatives

Among the approaches considered for improving the existing CM04 method for VOC collection and analyses, were changes to the sampling analyses and variations of the adsorbents used in the

sampling analyses. The difficulty appears to be that those factors that are optimum for one group of analytes are inappropriate for another group of the 20 target analytes.

The combined factors of "safe" breakthrough volume, range of CM04 certified reporting limits, and observed measurement performance variations suggest the need for distributive sampling at multiple flow rates. There would be a need for special testing using collocated sampling at multiple flow rates and using different types of adsorbents; the distributive sampling approach would require the initial determination of breakthrough volumes and certifiable reporting ranges for each analyte, preferably based upon gas-phase spike testing. The interpretation of data collected routinely from collocated distributed volume samples would entail a substantial amount of additional effort in order to select the most representative values. It would also involve equipment revisions, significantly increased media and analytical costs, and added data reduction and reporting. Nevertheless, Methods TO-1 and IP-1B state that distributive sampling is typically recommended for VOC sampling programs.

4.6.8.4 Whole-Air Sampling

Whole-air sampling (i.e., canisters) involves the collection of sample air directly into a rigid or non-rigid container. Rigid containers include glass sample bulbs and passivated stainless steel canisters, and non-rigid containers include Tedlar or Teflon sampling bags. Sampling bags are seldom used in situations where reliable retention of very low concentration VOCs is critical, especially if analysis is performed several hours or days after sample collection. Passivated canisters are now commonly used for sampling VOCs and some SVOCs at both low and high concentrations. Passivated canisters are popularly referred to as "Summa canisters" referring to the proprietary metallurgical electropolishing process developed by Molectrics, Inc. The electropolishing of the sampling canisters' inner surface substantially enhances preservation of sampling integrity. Holding times for samples collected in Summa passivated canisters are typically longer than those for adsorbent cartridges. Multiple analyses are possible with canister samples. Sample collection with canisters is performed either by pressurization with a pumping system or vacuum collection with a low flow regulator. Many configurations of sampling

systems have been developed commercially and some have been based upon EPA concepts. The important factors in canister sampling for RMA purposes are cleanliness inside the canisters, a sample delivery system free of contamination, and a constant flow rate during the sampling period. The simplest approach for 24-hour sampling involves the use of a 15L evacuated canister and a stainless steel vacuum regulator. Some users of this configuration have reported successful results in constant flow control over a 24-hour sampling period. An alternative configuration could involve the use of a pump in the sampling system to pressurize the canister.

A variety of methods have been developed for canister sample analysis. Typically, these have included GCMS-Scan, GCMS-Selective Ion Mode (SIM), or GCMS-Multidetector with a front end water management system to avoid cryotrap freeze-up. The water management systems usually include a Nafion dryer, which removes water from the sample stream, but while removing water with a Nafion dryer, polar compounds may also be removed. Such problems have been reduced or eliminated with the use of other apparatus recently developed by various manufacturers.

Disadvantages and advantages of sampling with passivated canisters are further discussed in Section 4.6.9.

4.6.8.5 Summary

The following is a summary of conclusions and recommendations pertaining to the improvement of the CAQMMP VOC sampling program:

- The existing VOC sampling and analytical method has certain limitations; additional tests and comparisons are needed to optimize the existing method or to select an alternative method.

- Reducing the volume flow rate from 200 sccm to 150 sccm has effectively reduced the front-to-back cartridge breakthrough percentage; several analytes, however, still exceed

the recommended breakthrough limit of 20 percent. In addition, several analytes now exhibit increased "greater than" levels.

- If the laboratory or the CM04 Method can accommodate a wider certified range, some of the negative effects of reduced flow might be eliminated. This could be investigated, but there are technical difficulties with this approach.

- Distributive sampling (multiple flow rates) is an EPA recognized procedure for VOC sampling where multiple analytes of different volatility are involved. The fact that the reduced flow rate produced more "greater than" and some decreased "greater than" CRL values, as well as more frequent "less than" and some decreased "less than" CRL values, attest to the unique physical characteristic of each of the RMA target compounds. Distributive sampling would address the physical qualities of each analyte and optimize the CM04 method. This approach would require increased development, and operational and analytical costs. It should be noted that the current data reviewed in this evaluation apply to samples collected during lower temperature winter time conditions, which is also a factor in performance.

- The canister approach is a recognized and viable alternative method for VOC sampling. The method has gained acceptance and may be effectively incorporated into the CAQMMP. An increased development effort would be required to ensure reliability and acceptability of the methods for RMA purposes, but operation costs would probably be comparable or less, once procedures were established.

- A final concern is the impact of any VOC methods change on the CMP/CAQMMP database. Improved methods may influence conclusions drawn concerning potential RMA toxic impacts and remedial progress to date. It should be noted, however, that the limitations of the VOC database have been consistently documented in previous

CMP/CAQMMP annual reports. Consequently, improvement of this database remains a desirable goal of the program.

4.6.9 Canister Versus Tube VOC Sampling

4.6.9.1 Background

The sampling and analysis of VOCs has been an integral part of the CMP and the present CAQMMP at RMA. The general VOC sampling method used at RMA has always consisted of drawing air samples through solid sorbents packed in either glass tubes (during the CMP) or stainless steel tubes (during the CAQMMP). The front tube contains Tenax sorbent; the rear tube contains Tenax followed by charcoal. The samples are typically taken for 24 hours at flow rates of 200 standard cubic centimeters per minute (sccm) for the CMP to 150 sccm for the CAQMMP. As discussed in the previous section, this tube sampling method suffers from problems with potential sample breakthrough, artifact formation, and fixed upper CRLs (see the more detailed discussion in Section 4.6.8). For example, in FY93 there were more than 350 exceedances of the upper CRL, which have been reported as "greater than" (GT) CRL values in the IRDMIS data base. Advantages and disadvantages of the method are presented in Table 4.6-13.

An alternative VOC sampling method that is gaining wide acceptance and avoids the major problems associated with sorbent tube sampling uses passivated stainless steel canisters. Whole air samples can be collected with this method for either short or integrated time periods (such as 24 hours). The samples are cryogenically concentrated in the laboratory before analysis. Advantages of using of canisters include the elimination of problems associated with sorbent breakthrough and the need for optimizing flow rates or utilizing distributive sampling with multiple tubes. Another advantage is that in general only one sample will need to be analyzed using canisters whereas the sorbent tube method requires that both the front and back tubes be analyzed which typically doubles analytical costs. Additionally, the canister method allows multiple analytical runs to be made on a single sample, if necessary, and allows for high end

Table 4.6-13 Tenax® Sampling Medium

Methods	Application	Advantages	Disadvantages
TO-1 Ambient Vost	Volatile, nonpolar organics boiling point 80° - 200°C	1) Compact sampling tubes, especially stainless steel. 2) Easy to handle and ship. 3) Analytical equipment commercially available. 4) May use standards in methanol solution or static dilution bulb. 5) Field-ready tubes can be purchased. 6) Low Detection Limits by concentrating large sample volumes.	1) Polymer contaminates easily. 2) Breakthrough volumes largely unknown. 3) "one-Shot" analysis. 4) Analysis produces artifacts. 5) Distributed volumes backup tube(s) required. 6) Low breakthrough for very volatile compounds. 7) Samples contain water. 8) Cost due to the need for distributed volume sampling and analysis.

Source: Merrill, R.G. Jr., et al (1990). "Practical Experience in Analysis of Organic Compounds in Ambient Air Using Canisters and Sorbents". AWMA 83rd Annual Meeting, Paper 90-170.4, Pittsburgh, PA., June 24-29.

Table 4.6-14 Summa® Polished Canister Sampling Medium

Methods	Application	Advantages	Disadvantages
TO-12 TO-14	Volatile and Semi-volatile organic compounds	1) Canister allows multiple analyses. 2) Can be screened, diluted. 3) Rugged for field handling, shipping. 4) Field-ready canisters, sampling equipment can be rented. 5) Sampling can be done without power. 6) Samples as taken accurately represent field atmosphere. 7) No need to collect distributed volume samples (no breakthrough).	1) High initial cost to purchase. 2) Much of the equipment required to support canister use is not commercially available. 3) Canisters are bulky to ship. 4) Canisters may produce analytical artifacts. 5) Samples contain a large amount of water. 6) Higher detection limits than most sorbent methods.

Source: Merrill, R.G. Jr., et al (1990). "Practical Experience in Analysis of Organic Compounds in Ambient Air Using Canisters and Sorbents". AWMA 83rd Annual Meeting, Paper 90-170.4, Pittsburgh, PA., June 24-29.

quantification. Table 4.6-14 presents the major advantages and disadvantages of the canister sampling method.

4.6.9.2 Canister Versus Tube Test Results

During FY93, PMRMA authorized the testing and comparison of the CM04 method for VOC analysis using Tenax and Tenax/charcoal tubes versus Summa canisters. Intensive testing was conducted on three routine (6-day) monitoring periods, August 29, September 4, and September 10, 1993. Collocated pairs of tubes and canisters were placed at six RMA monitoring sites: AQ2, AQ3, AQ5, AQ6, SQ1, and SQ2; an additional collocated canister was placed at SQ2.

The results of the comparison for each analyte compound for each monitoring day and at each sampling site are shown sequentially in Table 4.6-15; it is difficult to provide a quantitative summary of these comparisons, although the percent difference of the two methods for each collocated analysis is provided in the table. As noted, there are many cases where the tube measurement was below the CRL or the canister result was below the laboratory detection limit; these cases are noted as "NA" in the percent difference column of Table 4.6-15, although a qualitative evaluation can also be discerned from these data.

Many results are comparable, while others show excessive differences. In particular, the data on September 4 show great variability. It is believed that the CM04 tube data on this date are suspect as they are internally inconsistent and are also much larger than the canister results (nevertheless, all results are provided in this summary). There are a number of cases where the tubes indicated low values and the canisters were "below detection", but at a higher level than the tubes. This might be considered a good match, however these cases are indicated as N/A on Table 4.6-15; it does indicate a present advantage of CM04 tube method as the tubes can generally be certified at lower levels than canisters.

On the other hand, except for the September 4, 1993 data, the canister results were on average higher than the tubes; this is believed to be a valid attribute of the canister method. Also, there

Table 4.6-15 Tenax and Tenax/Charcoal Tubes Versus Canister Volatile Organic Compound Results

Date	Site identification	Analyte		Tubes (μg/m³)		Canister (μg/m³)	Percent Difference
08/29/93	AQ2	111TCE		1.210		1.254	-4
08/29/93	AQ3	111TCE		0.990		0.982	1
08/29/93	AQ5	111TCE		0.960		1.309	-27
08/29/93	AQ6	111TCE		0.740		1.145	-35
08/29/93	SQ1	111TCE		0.830		1.145	-27
08/29/93	SQ2	111TCE		1.210		1.145	6
09/04/93	AQ2	111TCE		4.800	LT	0.545	NA
09/04/93	AQ3	111TCE		4.000		1.091	267
09/10/93	SQ1	111TCE		1.240		1.091	14
09/12/93	M526SE	111TCE		0.850		0.982	-13
09/12/93	M326E	111TCE		0.909		6.163	-85
09/10/93	AQ2	111TCE		1.327		5.399	-75
09/10/93	AQ3	111TCE		0.875		0.927	-6
09/10/93	SQ2	111TCE		1.420		1.145	24
08/29/93	AQ2	C6H6		2.220		2.171	2
08/29/93	AQ3	C6H6		1.420		1.437	-1
08/29/93	AQ5	C6H6		0.520		1.788	-71
08/29/93	AQ6	C6H6		0.230		1.437	-84
08/29/93	SQ1	C6H6		1.110		1.501	-26
08/29/93	SQ2	C6H6		1.310		1.501	-13
09/04/93	AQ2	C6H6		11.900	LT	0.319	NA
09/04/93	AQ3	C6H6		9.800		1.181	730
09/10/93	SQ1	C6H6		1.080		0.990	9
09/12/93	M526SE	C6H6		1.240		1.469	-2
09/12/93	M326E	C6H6		1.516		1.724	-12
09/10/93	AQ2	C6H6		1.429		1.596	-10
09/10/93	AQ3	C6H6		0.880		1.980	-56
09/10/93	SQ2	C6H6		1.119		0.958	17
08/29/93	AQ2	CCL4		0.540		0.629	-14
08/29/93	AQ3	CCL4		0.550		0.629	-13
08/29/93	AQ5	CCL4		0.315	LT	0.629	NA
08/29/93	AQ6	CCL4		0.340	LT	0.629	NA
08/29/93	SQ1	CCL4		0.690		0.629	10
08/29/93	SQ2	CCL4		0.550		0.629	-13
09/04/93	AQ2	CCL4		5.400	LT	0.629	NA
09/04/93	AQ3	CCL4		1.500		0.755	99
09/10/93	SQ1	CCL4		0.700		0.755	-7
09/12/93	M526SE	CCL4		0.450		0.692	-35
09/12/93	M326E	CCL4		0.633		0.692	-9
09/10/93	AQ2	CCL4		0.664		0.755	-12
09/10/93	AQ3	CCL4		0.539		0.692	-22
09/10/93	SQ2	CCL4		0.833		0.692	20
08/29/93	AQ2	CH2CL2	LT	0.463		2.673	NA
08/29/93	AQ3	CH2CL2	LT	0.463		2.846	NA
08/29/93	AQ5	CH2CL2	LT	0.463		2.291	NA
08/29/93	AQ6	CH2CL2	LT	0.463		2.326	NA

LT ### - Less than certified reporting limit
NA - Not applicable
μg/m³ - Micrograms per cubic meter
CHCL3 - Chloroform
CH2CL2 - Methylene chloride
ETC6H5 - Ethylbenzene
MECGH5 - Toluene
TLLEE - Tetrachloroethene
Xylenes - Total xylenes

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Table 4.6-15 Tenax and Tenax/Charcoal Tubes Versus Canister Volatile Organic Compound Results

Date	Site identification	Analyte		Tubes (μg/m³)		Canister (μg/m³)	Percent Difference
08/29/93	SQ1	CH2CL2		0.480		1.909	-75
08/29/93	SQ2	CH2CL2	LT	0.463		2.083	NA
09/04/93	AQ2	CH2CL2		2.700	LT	0.347	NA
09/12/93	M326E	CH2CL2	LT	0.463		0.555	NA
09/10/93	AQ2	CH2CL2		1.067		1.111	-4
09/10/93	AQ3	CH2CL2		2.043		0.417	390
09/10/93	SQ2	CH2CL2		2.643		0.486	444
08/29/93	AQ2	CHCL3	LT	0.056	LT	0.488	NA
08/29/93	AQ3	CHCL3		0.130	LT	0.488	NA
08/29/93	AQ5	CHCL3		0.090	LT	0.488	NA
08/29/93	AQ6	CHCL3	LT	0.056	LT	0.488	NA
08/29/93	SQ1	CHCL3		0.760		0.488	56
08/29/93	SQ2	CHCL3		0.508		0.683	-26
09/04/93	AQ2	CHCL3		13.570	LT	0.488	NA
09/04/93	AQ3	CHCL3		1.070	LT	0.488	NA
09/10/93	SQ1	CHCL3		0.350	LT	0.488	NA
09/12/93	M526SE	CHCL3		0.250	LT	0.488	NA
09/12/93	M326E	CHCL3	LT	0.056	LT	0.488	NA
09/10/93	AQ2	CHCL3		0.220	LT	0.488	NA
09/10/93	AQ3	CHCL3		0.240	LT	0.488	NA
09/10/93	SQ2	CHCL3		0.437	LT	0.488	NA
08/29/93	AQ2	ETC6H5		0.810		0.695	17
08/29/93	AQ3	ETC6H5		0.640	LT	0.434	NA
08/29/93	AQ5	ETC6H5	LT	0.148		0.608	NA
08/29/93	AQ6	ETC6H5	LT	0.148		0.478	NA
08/29/93	SQ1	ETC6H5	LT	0.148		0.478	NA
08/29/93	SQ2	ETC6H5	LT	0.148		0.478	NA
09/04/93	AQ2	ETC6H5		2.800	LT	0.434	NA
09/04/93	AQ3	ETC6H5		5.000		1.563	220
09/10/93	SQ1	ETC6H5		0.330	LT	0.434	NA
09/12/93	M526SE	ETC6H5		0.560		0.608	-8
09/12/93	M326E	ETC6H5		0.339		1.303	-74
09/10/93	AQ2	ETC6H5		0.493		1.042	-53
09/10/93	AQ3	ETC6H5		0.318	LT	0.434	NA
09/10/93	SQ2	ETC6H5		0.423	LT	0.434	NA
08/29/93	AQ2	MEC6H5		5.700		7.681	-26
08/29/93	AQ3	MEC6H5		3.900		3.577	9
08/29/93	AQ5	MEC6H5		0.170		5.460	-97
08/29/93	AQ6	MEC6H5		0.150		6.853	-98
08/29/93	SQ1	MEC6H5		0.310		4.255	-93
08/29/93	SQ2	MEC6H5		0.410		3.878	-89
09/10/93	SQ1	MEC6H5		2.600		3.163	-18
09/12/93	M526SE	MEC6H5		3.400		4.255	-20
09/12/93	M326E	MEC6H5		2.000		14.459	-86
08/29/93	AQ2	TCLEE		0.470		0.949	-50
08/29/93	AQ3	TCLEE		0.390	LT	0.678	NA

LT ### - Less than certified reporting limit
NA - Not applicable
μg/m³ - Micrograms per cubic meter
CHCL3 - Chloroform
CH2CL2 - Methylene chloride
ETC6H5 - Ethylbenzene
MEC6H5 - Toluene
TCLEE - Tetrachloroethene

Table 4.6-15 Tenax and Tenax/Charcoal Tubes Versus Canister Volatile Organic Compound Results

Date	Site identification	Analyte		Tubes (μg/m³)		Canister (μg/m³)	Percent Difference
08/29/93	AQ5	TCLEE	LT	0.060	LT	0.678	NA
08/29/93	AQ6	TCLEE	LT	0.060	LT	0.678	NA
08/29/93	SQ1	TCLEE	LT	0.060	LT	0.678	NA
08/29/93	SQ2	TCLEE	LT	0.060	LT	0.678	NA
09/10/93	SQ1	TCLEE		0.290	LT	0.678	NA
09/10/93	AQ2	TCLEE		0.314		0.746	-58
09/10/93	AQ3	TCLEE		0.220	LT	0.678	NA
09/10/93	SQ2	TCLEE		0.268	LT	0.678	NA
08/29/93	AQ2	TRCLE	LT	0.056	LT	0.537	NA
08/29/93	AQ3	TRCLE	LT	0.056		0.860	NA
08/29/93	AQ5	TRCLE	LT	0.056	LT	0.537	NA
08/29/93	AQ6	TRCLE	LT	0.056		0.732	NA
08/29/93	SQ1	TRCLE	LT	0.056	LT	0.537	NA
08/29/93	SQ2	TRCLE	LT	0.056		0.591	NA
09/04/93	AQ2	TRCLE		0.380	LT	0.537	NA
09/04/93	AQ3	TRCLE		0.150		1.733	-91
09/10/93	SQ1	TRCLE	LT	0.056	LT	0.537	NA
09/12/93	M526SE	TRCLE	LT	0.056		1.655	NA
09/12/93	M326E	TRCLE	LT	0.056	LT	0.537	NA
09/10/93	AQ2	TRCLE	LT	0.056	LT	0.537	NA
09/10/93	AQ3	TRCLE	LT	0.056		0.645	NA
09/10/93	SQ2	TRCLE	LT	0.056		0.806	NA
08/29/93	AQ2	XYLENES		3.600		3.170	14
08/29/93	AQ3	XYLENES		3.200		1.867	71
08/29/93	AQ5	XYLENES	LT	0.690		2.779	NA
08/29/93	AQ6	XYLENES	LT	0.690		2.214	NA
08/29/93	SQ1	XYLENES	LT	0.690		2.214	NA
08/29/93	SQ2	XYLENES	LT	0.690		2.214	NA
09/04/93	AQ2	XYLENES		12.000	LT	0.434	NA
09/04/93	AQ3	XYLENES		23.000		2.084	1004
09/10/93	SQ1	XYLENES		1.500		1.824	-18
09/12/93	M526SE	XYLENES		2.700		3.170	-15
09/12/93	M326E	XYLENES		1.842		6.686	-72
09/10/93	AQ2	XYLENES		2.407		4.038	-40
09/10/93	AQ3	XYLENES		1.519		1.824	-17
09/10/93	SQ2	XYLENES		2.276		1.997	14

LT ### - Less than certified reporting limit
NA - Not applicable
μg/m³ - Micrograms per cubic meter
TCLEE - Tetrachloroethene
TRCLE - Trichloroethene
Xylenes - Total xylenes

is good internal consistency in the canister data results. This can be ascertained from a cursory examination of the canister and tube data columns in Table 4.6-15. More significantly, Table 4.6-16 shows canister precision comparisons for the two collocated canister samples collected at station SQ2. Except for several outlyers (benzene on August 29; toluene on August 29; and methylene chloride on September 10), canister collocated sample results are more consistent than those routinely obtained for the CM04 tube method over the past several years.

Additional refinements in the canister collection method and laboratory analyses are currently being investigated by the CAQMMP. It is possible that some VOC compounds may respond more favorably than others to the standard canister analysis procedures; again, this will be investigated. However, it is anticipated that the use of passivated canisters will be employed on a partial or full basis at RMA in FY95.

4.6.10 VOC Nontarget Analyte Results

When a sample is analyzed for VOCs with the GC/MS, results are only reported for target analytes with certified concentration ranges. Additional nontarget analyte peaks appearing on the chromatogram at greater than 10 percent of the internal standard area can be tentatively identified matching the spectra using a computer. IRDMIS refers to these tentatively identified compounds (TICs) as unknowns (UNKs) and labels them according to their relationship with the retention time of the internal standard as follows:

$$\text{UNK No.} = \frac{\text{Retention time of unknown}}{\text{Retention time of Internal Standard}} * 100$$

While the unknown numbers or units do not correlate to specific TICs, the laboratory provided a listing of most probable matches. These data are summarized in Table 4.6-17.

Table 4.6-16 Canister Precision Comparisons

Analyte	August 29, 1993 Primary $\mu g/m^3$	August 29, 1993 Duplicate $\mu g/m^3$	August 29, 1993 Relative Percent Difference	September 4, 1993 Primary $\mu g/m^3$	September 4, 1993 Duplicate $\mu g/m^3$	September 4, 1993 Relative Percent Difference	September 10, 1993 Primary $\mu g/m^3$	September 10, 1993 Duplicate $\mu g/m^3$	September 10, 1993 Relative Percent Difference
111TCE	1.145	1.200	-5	1.691	1.691	0	1.145	1.145	0
112TCE	<0.545	<0.545	0	<0.545	<0.545	0	<0.545	<0.545	0
11DCLE	<0.405	<0.405	0	<0.405	<0.405	0	<0.405	<0.405	0
12DCLE	<0.405	<0.405	0	<0.405	<0.405	0	<0.405	<0.405	0
12DCE	<0.396	<0.396	0	<0.396	<0.396	0	<0.396	<0.396	0
C6H6	1.501	0.607	85	3.448	3.608	-5	0.958	0.926	3
CCL4	0.629	0.629	0	0.817	0.817	0	0.692	0.755	-9
CH2CL2	2.083	1.770	16	0.937	1.007	-7	0.486	0.764	-44
CHCL3	0.683	<0.488	NA	0.635	0.683	-7	<0.488	<0.488	0
CLC6H5	<0.460	<0.460	0	<0.460	<0.460	0	<0.460	<0.460	0
ETC6H5	0.478	<0.434	NA	1.606	1.693	-5	<0.434	1.129	NA
MEC6H5	3.878	1.093	112	11.823	10.807	9	3.088	2.447	23
TCLEE	<0.678	<0.678	0	1.085	1.017	0	<0.678	<0.678	0
TRCLE	0.591	<0.537	NA	1.558	<0.537	NA	0.806	<0.537	NA
XYLENES	2.214	<0.434	NA	7.815	8.770	-12	1.997	0.612	106

< ### - Indicates the concentration is less than the lower certified reporting limit
NA - Not Applicable
$\mu g/m^3$ - Micrograms per cubic meter

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Table 4.6-17 Summary of FY93 Tentatively Identified Volatile Organic Compound Data

Tentatively Identified Compound	Number of Detections
Cyclohexane, methyl-	226
Benzene, 1-ethyl-2-methyl-	226
Hexane	119
Octane	92
Benzene, 1-ethyl-4-methyl-	92
Benzene, 1-ethyl-3-methyl-	66
.alpha.-Pinene	52
Decane	43
Benzene, 1,2,4-trimethyl-	30
Pentane	27
Benzene, 1,2,3-trimethyl-	25
Cyclopentane, methyl-	19
Butylated Hydroxytoluene	18
Heptane	17
Butane, 2-methyl-	16
Benzene, 1,3,5-trimethyl-	13
Acetophenone	10
Pentane, 2-methyl-	8
Naphthalene, 2-methyl-	8
Methane, trichlorofluoro-	8
Benzene, 1,3-dimethyl-	8
Benzene, 1,2-dimethyl-	8
1,2-Benzenedicarboxylic acid, 3-nitro-	8
Methane, dichloro-	7
1-Hexanol, 2-ethyl-	7
Naphthalene, 1,7-dimethyl-	6
Naphthalene, 1,4-dimethyl-	6
Naphthalene, 1,2-dimethyl-	6
Heptane, 2-methyl-	6
Benzene, (1-methylethyl)-	6
2-Propenoic acid, 3-phenyl-, ethyl ester	6
Naphthalene, 1-methyl-	5
Hexadecane	5
Dodecane, 2-methyl-6-propyl-	5
Bicyclo[3.1.1]hept-2-ene, 3,6,6-trimethyl-	5
Benzene, 2,4-diisocyanato-1-methyl-	5
4-Carene, (1S,3S,6R)-(-)-	5
Nonane	4
Heptane, 3-methylene-	4
Ethene, 1,2-dichloro-, (Z)-	4
Dodecane	4
Cyclotrisiloxane, hexamethyl-	4
Camphene	4
Bis(2-ethylhexyl) phthalate	4
Phenothiazine	3
Octacosane	3
Naphthalene, 2,3-dimethyl-	3
Naphthalene, 1,8-dimethyl-	3
Hexanedioic acid, bis(2-ethylhexyl) ester	3
Heptadecane, 2,6,10,15-tetramethyl-	3
Ethene, 1,2-dichloro-, (E)-	3
Dibutyl phthalate	3
Decane, 2,3,5-trimethyl-	3
1,3-Benzenediamine, 2-methyl-	3
Phenothiazine	2
Pentacosane	2
Naphthalene, 1,6-dimethyl-	2
Limonene	2

Table 4.6-17 Summary of FY93 Tentatively Identified Volatile Organic Compound Data

Tentatively Identified Compound	Number of Detections
Hexatriacontane	2
Hexanoic acid, 2-ethyl-	2
Hexane, 3-methyl-	2
Eicosane	2
Diethyl Phthalate	2
Benzene, 1-ethenyl-4-ethyl-	2
Benzene, 1,4-dimethyl-	2
1,3,6-Octatriene, 3,7-dimethyl-, (E)-	2
1,2-Benzenedicarboxylic acid, diisooctyl ester	2
.alpha.-L-Galactofuranose, 6-deoxy-1,2,3,5-tetraki	2
Triethylenediamine	1
Tridecane	1
Propanoic acid, 2-methyl-, 3-hydroxy-2,4,4-trimeth	1
Pentadecane	1
Oleic Acid	1
Octadecane, 5,14-dibutyl-	1
Nonadecane	1
Naphthalene, 2-ethenyl-	1
Naphthalene, 1,5-dimethyl-	1
Methane, dimethoxy-	1
Methane, chloro-	1
Hexane, 2,4-dimethyl-	1
Heptane, 3-methyl-	1
Heptadecane	1
Heneicosane	1
Furan, 2,5-dihydro-2,5-dimethyl-	1
Ethene, 1,1-dichloro-	1
Eicosane, 7-hexyl-	1
Docosane	1
D-Limonene	1
Cyclopentasiloxane, decamethyl-	1
Cyclododecane	1
Bis(2-methoxyethyl) phthalate	1
Bicyclo[4.2.0]octa-1,3,5-triene	1
Bicyclo[2.2.1]hept-2-ene, 1,7,7-trimethyl-	1
Benzoic acid, ammonium salt	1
Benzene, 4-pentenyl-	1
Benzene, 1-methyl-3-(1-methylethyl)-	1
Benzene, 1-methyl-2-(1-methylethyl)-	1
Benzene, 1,4-dichloro-	1
Benzene, 1,3-dimethyl-	1
Benzene, 1,3-dichloro-	1
Benzene, 1,3,5-tris(3-methyl-3-butenyl)-	1
Benzene, 1,2-dichloro-	1
Benzene, (2-methyl-1-butenyl)-	1
4-Carene, (1S,3R,6R)-(-)-	1
2-Undecanone, 6,10-dimethyl-	1
2-Propenoic acid, 3-(4-methoxyphenyl)-, 2-ethylhex	1
2-Pentadecanone, 6,10,14-trimethyl-	1
2,5-Cyclohexadiene-1,4-dione, 2,6-bis(1,1-dimethyl	1
1-Octadecanol	1
1,2-Pentadiene	1
1,2-Benzenedicarboxylic acid, bis(2-methoxyethyl)	1
1,1'-Biphenyl	1

4.7 SEMIVOLATILE ORGANIC COMPOUNDS AND ORGANOCHLORINE PESTICIDES

4.7.1 Monitoring, Analysis and Reporting Strategies

SVOC and OCP monitoring, which provide measurements of pesticide levels at the RMA interior and perimeter sites, are described in this section. During FY93, routine OCP monitoring was employed to measure pesticide levels at RMA. In FY91, OCP monitoring replaced SVOC monitoring as the principal method for pesticide monitoring. The change was the result of experience and analysis of several different methods to determine the most effective means of collecting and measuring pesticides. The F-7 GC/MS method, an MRI certified method, was initially used during Basin F remediation for analyses of SVOCs, and the H-7 GC/ECD method was used for the analyses of OCPs. During the FY88 Basin F remedial period, the H-7 GC/ECD method was also used to confirm low levels of SVOC pesticides. The H-7 method was approximately 100 times more sensitive to pesticides than the F-7 method, and in FY89 and FY90, there were no detections under the F-7 method; consequently, the more sensitive H-7 method identified pesticides for both of these periods for the Basin F and IRA-F monitoring program.

In FY90, when the ESE laboratory was selected for CMP analyses, method CM03 (GC/MS) was certified for SVOC analyses, and method CH01 (GC/ECD) for OCP analyses. These methods, however, displayed the same characteristics as before. OCPs were readily detected, while SVOCs were generally below detection. In FY93, the OCP method was used exclusively for routine monitoring; the SVOC method was used for high-event monitoring to present a broader suite of potential compounds and to ensure that SVOCs did not occur at levels of concern (as they did on occasion during Basin F remediation).

Routine OCP monitoring consisted of weekly sampling at 12 sites (including collocated stations) and monthly sampling at two sites. SVOCs were monitored monthly at two sites, seasonally at 8 sites, and for 12 high-event episodes. Table 3.2-2 provides details of the sampling schedule. A summary of OCP monitoring, including sampling sites, number of samples, and recoveries, is provided in Table 4.7-1. The high-event schedule (for SVOCs) is provided in Table 4.7-2.

Table 4.7-1 Summary of Organochlorine Pesticide Monitoring for FY93

Station	Samples Scheduled	Samples Collected	Valid Samples	Field % Recovery	Overall % Recovery
AQ2	61	58	57	95	93
AQ3	61	57	56	93	92
AQ5	61	60	57	98	93
AQ6	61	56	55	92	90
AQ8	61	57	57	93	93
AQ9	61	55	55	90	90
FC1	61	56	56	92	92
FC2	61	58	57	95	93
FC3	12	11	11	92	92
FC4	12	12	12	100	100
FC5	61	57	57	93	93
SQ1	61	55	55	90	90
SQ2	61	56	56	92	92
Duplicate	61	57	57	93	93
Overall	756	705	698	93	92

Table 4.7-2 FY93 Semivolatile Organic Compound High-Event Sampling Locations

Date	Target Area	Duration (Hours)	Sampling Locations
12/11/92*	Basin F	1100 - 1100	AQ2, AQ3, AQ5, AQ6, FC1, FC2
1/14/93	Seasonal	1000 - 1000	AQ1, AQ2, AQ3, AQ4, AQ5, AQ6, AQ8
1/22/93*	Basin F	1300 - 1300	AQ2, AQ3, AQ5, AQ6, FC2, FC4
2/24/93	Seasonal	1200 - 1200	AQ1, AQ2, AQ3, AQ4, AQ5, AQ6, AQ8
3/4/93	Submerged Quench Incinerator (baseline)	1200 - 1200	AQ2, AQ3, AQ5, AQ6, SQ1, SQ2, FC2, M1E
4/10/93	Basin A	1500 - 1500	AQ2, AQ3, AQ5, AQ6, M136E, M236W
5/13/93	Hydrazine Plant	1100 - 1100	AQ2, AQ5, AQ6, AQ9, M101E, M201W
6/3/94	Seasonal	1100 - 1100	AQ1, AQ2, AQ3, AQ4, AQ5, AQ6, AQ8
6/12/94	Submerged Quench Incinerator (trial burn)	0700 - 0700	AQ3, AQ6, SQ1, SQ2, FC2, M125W
6/24/93	Basin A Excavation Activities	1300 - 1300	FC1, AQ8, AQ9, M336E, M436W
6/30/93	Basin F	1100 - 1100	FC3, FC4, AQ11, M226E
7/15/93	Basin A Soil Sifting	0700 - 1500 (8 hours)	AQ1, AQ4, AQ5, AQ8, AQ9, AQ10, M601N, M701N
7/30/93	Section 27 Water Treatment Plant	1000 - 1000	AQ1 AQ4, AQ5, AQ8, AQ9, AQ10, M601N, M701
8/11/93	South Plants Area	1200 - 1200	AQ5, AQ6, AQ8, AQ9, M801N, M102E
8/29/93	Submerged Quench Incinerator	1300 - 1300	AQ3, AQ6, FC2, SQ1, SQ2, M225W
9/12/93	Basin F Waste Pile	1200 - 1200	FC2, FC3, FC4, M326E, M426S, M526SE
9/28/93	Pond A Liner Cleaning	1200 - 1200	AQ2, AQ11, AQ12, FC1, FC4, FC5

* Laboratory performed OCP analysis instead of SVOC analysis
OCP Organochlorine Pesticides
SVOC Semivolatile Organic Compounds

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4.7.2 The CAQMMP OCP Monitoring Results

Tables 4.7-3 and 4.7-4 present summaries of FY93 OCP monitoring results for all CAQMMP sampling sites at RMA. Table 4.7-3 shows the annual average, and Table 4.7-4 presents the 24-hour maximum concentrations of each OCP at each monitoring site. As in the case of VOCs, those OCPs below the CRL were assigned a value of one-half the detection limit for averaging purposes (shown in parentheses in Table 4.7-3).

Measured concentrations during FY93 at Basin F and at RMA perimeter sites were generally comparable to levels observed during the Basin F post-remedial period. The one exception was the AQ8 site, located just to the south of Basin A and north of the South Plants. Various construction and remedial activities were accomplished in the Basin A area during FY93, and several pesticides were measured at higher levels than in the recent past. These results will be discussed in further detail below. It is interesting that several of the OCPs measured at AQ8 were an order of magnitude higher than post-remedial OCPs at Basin F, but were nevertheless well below peak levels observed during the active Basin F remediation period.

The highest maximum 24-hour concentration of aldrin during FY93, 0.0023 $\mu g/m^3$, occurred at FC2D. This was well below the FY92 aldrin 24-hour maximum value of 0.0065 $\mu g/m^3$ (at FC2) and significantly below the peak value of 0.8366 $\mu g/m^3$ during active Basin F remediation. The FY93 annual average aldrin level was 0.00023 $\mu g/m^3$ at FC2, compared to 0.00021 $\mu g/m^3$ in FY92. Aldrin levels at the Basin A site, AQ8 were slightly higher than the recent past with a 24-hour maximum level of 0.0018 $\mu g/m^3$, and an annual average of 0.0003 $\mu g/m^3$, which was the highest annual average of any of the sites.

The 24-hour maximum level of chlordane was 0.0360 $\mu g/m^3$ at AQ8; the second highest 24-hour level was 0.0150 $\mu g/m^3$ at AQ9 at the northern extremity of Section 36, northeast of Basin A. Chlordane appeared to be confined to the Basin A area. The maximum 24-hour chlordane concentration at Basin F was 0.0021 $\mu g/m^3$ at FC2. Chlordane did not appear to be a

Table 4.7-3 Summary of FY93 Average Organochlorine Pesticide Concentrations ($\mu g/m^3$)

Station	Aldrin	Chlordane	Dieldrin	Endrin	Isodrin	PPDDE	PPDDT
AQ2	<0.0003 (0.00015)	<0.0003 (0.00019)	<0.0003 (0.00019)	<0.0003 (0.00015)	<0.0003 (0.00015)	<0.0003 (0.00015)	<0.0003 (0.00015)
AQ3	<0.0003 (0.00015)	<0.0003 (0.00021)	<0.0003 (0.00021)	<0.0003 (0.00015)	<0.0003 (0.00015)	<0.0003 (0.00015)	<0.0003 (0.00015)
AQ5	<0.0003 (0.00015)	<0.0003 (0.00019)	<0.0003 (0.00018)	<0.0003 (0.00015)	<0.0003 (0.00015)	<0.0003 (0.00015)	<0.0003 (0.00015)
AQ6	<0.0003 (0.00017)	0.0006 (0.00056)	0.0007 (0.00069)	<0.0003 (0.00015)	<0.0003 (0.00015)	<0.0003 (0.00015)	<0.0003 (0.00015)
AQ8	0.0003	0.0041	0.0046	0.0008	<0.0003 (0.00019)	<0.0003 (0.00016)	0.0003
AQ9	<0.0003 (0.00018)	0.0014	0.0008	<0.0003 (0.00018)	<0.0003 (0.00015)	<0.0003 (0.00015)	<0.0003 (0.00015)
FC1	<0.0003 (0.00018)	0.0003	0.0007	<0.0003 (0.00016)	<0.0003 (0.00015)	<0.0003 (0.00015)	<0.0003 (0.00015)
FC2	<0.0003 (0.00023)	0.0003	0.0020	<0.0003 (0.00024)	<0.0003 (0.00015)	<0.0003 (0.00015)	<0.0003 (0.00015)
FC3	<0.0003 (0.00021)	0.0004	0.0021	<0.0003 (0.00020)	<0.0003 (0.00015)	<0.0003 (0.00015)	<0.0003 (0.00015)
FC4	<0.0003 (0.00015)	<0.0003 (0.00020)	0.0005	<0.0003 (0.00015)	<0.0003 (0.00015)	<0.0003 (0.00015)	<0.0003 (0.00015)
FC5	<0.0003 (0.00018)	0.0003	0.0008	<0.0003 (0.00016)	<0.0003 (0.00015)	<0.0003 (0.00015)	<0.0003 (0.00015)
SQ1	<0.0003 (0.00015)	0.0003	0.0006	<0.0003 (0.00015)	<0.0003 (0.00015)	<0.0003 (0.00015)	<0.0003 (0.00015)
SQ2	<0.0003 (0.00016)	0.0004	0.0009	<0.0003 (0.00015)	<0.0003 (0.00015)	<0.0003 (0.00015)	<0.0003 (0.00015)

Note: < #### indicates average concentration was less than the lower certified reporting limit
( ) indicates computed average, when [average] is less than the lower certified reporting limit.
$\mu g/m^3$ Micrograms per cubic meter

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Table 4.7-4 Summary of FY93 24-Hour Maximum Organochlorine Pesticide Concentrations ($\mu g/m^3$)

Station	Aldrin	Chlordane	Dieldrin	Endrin	Isodrin	PPDDE	PPDDT
AQ2	<0.0003	0.0013	0.0010	<0.0003	<0.0003	<0.0003	<0.0003
AQ3	<0.0003	0.0012	0.0012	<0.0003	<0.0003	<0.0003	0.0005
AQ5	<0.0003	0.0007	0.0007	<0.0003	<0.0003	<0.0003	<0.0003
AQ6	0.0009	0.0038	0.0048	<0.0003	<0.0003	0.0006	<0.0003
AQ8	0.0018	0.0360	0.0430	0.0052	0.0012	<0.0003	0.0024
AQ9	0.0013	0.0150	0.0068	0.0008	<0.0003	<0.0003	<0.0003
FC1	0.0017	0.0016	0.0068	0.0004	<0.0003	<0.0003	<0.0003
FC2	0.0023	0.0021	0.0190	0.0013	<0.0003	<0.0003	0.0004
FC3	0.0006	0.0016	0.0120	0.0007	<0.0003	<0.0003	<0.0003
FC4	<0.0003	0.0007	0.0015	<0.0003	<0.0003	<0.0003	<0.0003
FC5	0.0015	0.0017	0.0059	0.0004	<0.0003	<0.0003	<0.0003
SQ1	<0.0003	0.0017	0.0051	0.0004	<0.0003	<0.0003	<0.0003
SQ2	0.0006	0.0029	0.0070	<0.0003	<0.0003	<0.0003	<0.0003

Note: < #### indicates concentration was less than the lower certified reporting limit
$\mu g/m^3$ Micrograms per cubic meter

contaminant of concern at Basin F during the remediation activities. The maximum annual chlordane average was 0.00407 μg/m^3 at AQ8; the second maximum average was 0.00143 μg/m^3 at AQ9. Other chlordane levels were quite low and primarily below detection.

Dieldrin was again highest at AQ8 where the 24-hour maximum concentration was 0.0430 μg/m^3 and the annual average was 0.00451 μg/m^3. Within the Basin F area, dieldrin reached a maximum 24-hour level of 0.0190 μg/m^3 at FC2 and a maximum average of 0.00214 μg/m^3. These concentrations were below FY92 levels, and considerably below active remediation levels when station BF2 reported a maximum 24-hour dieldrin level of 2.260 μg/m^3.

Endrin was also highest at AQ8 during FY93, with a maximum 24-hour concentration of 0.0052 μg/m^3 and an annual average of 0.00082 μg/m^3. The next highest levels were at FC2 with a 24-hour maximum value of 0.0013 μg/m^3 and an annual average of 0.00024 μg/m^3. Again they were comparable to Basin F post-remediated levels and well below Basin F remedial levels when a maximum endrin concentration of 1.0954 μg/m^3 was measured at station BF2C.

Isodrin was measured at the 24-hour maximum concentration of 0.0012 μg/m^3 and a maximum annual concentration of 0.00019 μg/m^3, both at AQ8. All other 24-hour concentrations of isodrin were below detection. During Basin F remediation, isodrin occasionally reached high levels with a maximum 24-hour concentration of 0.9450 μg/m^3 at station BF2C. Isodrin has been measured infrequently during the post-remedial period.

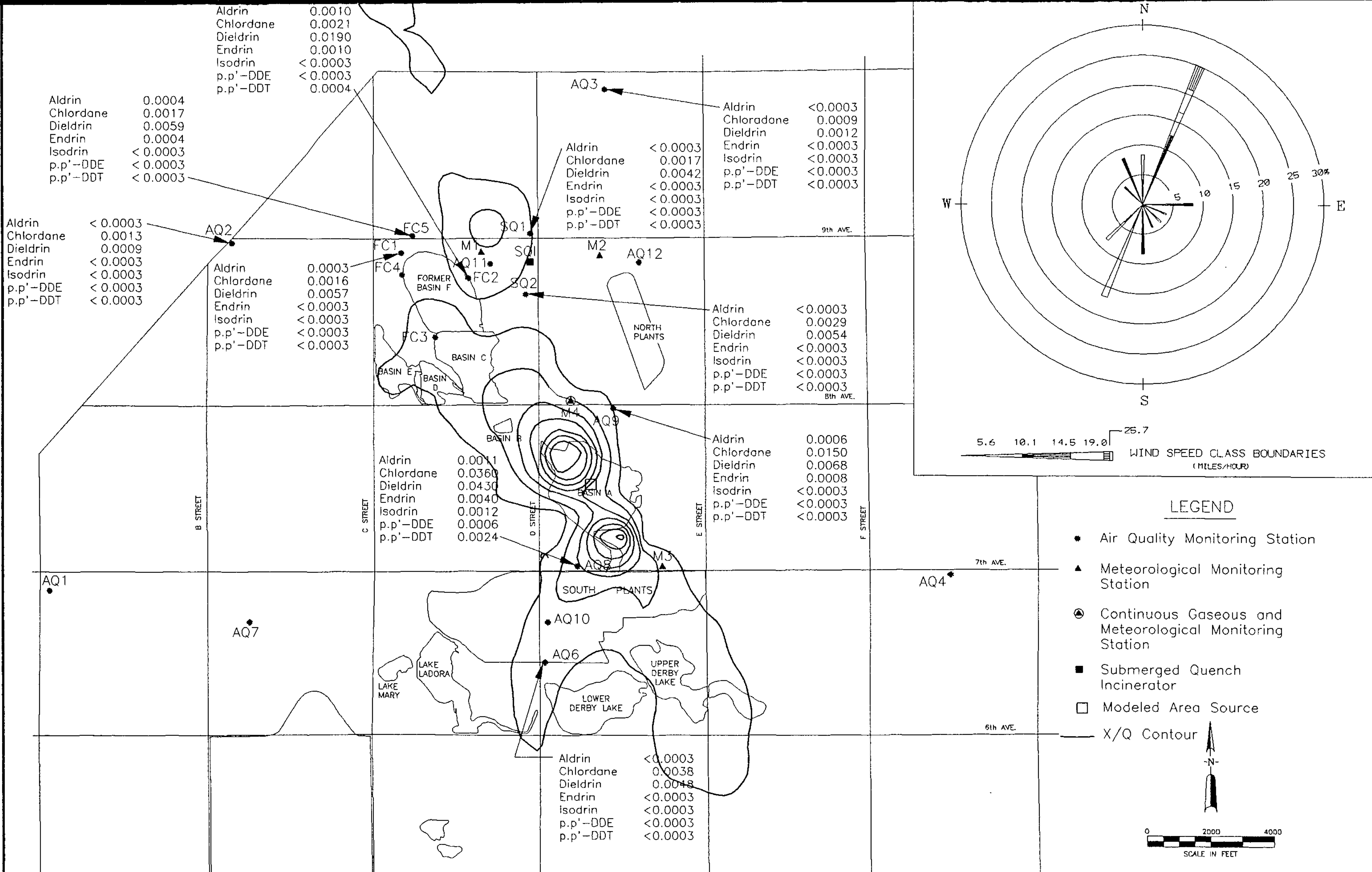
Both PPDDE and PPDDT were measured infrequently during FY93. The highest 24-hour maximum values were 0.0024 μg/m^3 for PPDDT, and 0.0006 μg/m^3 for PPDDE, both at AQ8. These concentrations appear to have been related to construction activities in the Basin A area and on the pipeline leading from Basin F to the SQI. The annual maximum averages at AQ8 were 0.0003 μg/m^3 for PPDDT and 0.0002 μg/m^3 for PPDDE. Almost all measurements at all sites (including AQ8) were below detection. These compounds did not appear to have been a

Basin F remediation concern but were occasionally measured at low levels during the Basin F remedial period.

4.7.3 High-Event and Special Day Monitoring

In accordance with the CAQMMP Technical Plan, high-event monitoring for SVOCs was conducted on 12 days in FY93 at locations and dates shown in Table 4.7-2. As previously noted, the detection level for SVOCs is considerably higher than for OCPs. Nevertheless the target list for SVOCs contains some 22 potential contaminants and an effort was made to screen these analytes for possible impacts from RMA activities. No SVOCs were detected, however, except for one measurement of dieldrin at 0.0540 $\mu g/m^3$ at a manhole cover near Building 511 on September 12, 1993. This level was slightly above the maximum dieldrin concentration measured at AQ8 using the OCP method. It is anticipated that future pesticide high events will be conducted for OCPs with additional SVOC screening during emergency events. It is important also to point out that in FY93, OCP monitoring was conducted as a backup on many of the SVOC high-event monitoring days.

It is of special interest that on those days identified with high VOC concentrations, especially the December 8, 1992 inversion episode when there was a brown cloud intrusion over RMA, OCP concentrations remained at low levels. This suggests that pesticides are confined to special areas of RMA where they were deposited during previous industrial or remediation activities. It appears that Basin A is one such area. During OCP monitoring on August 11, 1993, five pesticides were measured at their highest levels of the year and peak concentrations were centered around Basin A as illustrated in Figure 4.7-1. Ambient OCP concentrations and the X/Q dispersion pattern (with a potential source over Basin A) are shown in this figure. On this day, winds were primarily from the north-northeast, however, all directions were represented; wind speeds were strong and gusty at the beginning of the monitoring period, becoming light to moderate the remainder of the period. Temperatures reached the low 80s. Atmospheric stability was typical of a summer day—stable during the evening (classes 5 and 6), unstable at midday (classes 1 and 2), and neutral (class 4) during several strong wind speed periods. The dispersion



Prepared for:
U.S. Army Program Manager for Rocky Mountain Arsenal

Figure 4.7-1
OCP Results (ug/m^3) and X/Q Dispersion Pattern for 8/11/93

Rocky Mountain Arsenal
Prepared by: Ebasco Services Incorporated

pattern shows maximum X/Q values centered over the Basin A potential source area and extending northwest and southeast; it is interesting that this pattern reflects the hours of low wind speeds and stable atmospheric stability rather than prevailing wind flow under stronger wind speeds. However, the dispersion pattern corresponds closely to actual OCP concentrations with the highest levels of all pesticides at AQ8 and decreasing proportional northwest and southeast. As Basin F is also a potential source of several of these compounds, it is not surprising that moderate levels were also measured at the Basin F monitoring sites. However, perimeter sites AQ2 and AQ3, farther downwind and outside the principal dispersion patterns, measured very low or non-detectable concentrations. The August 11 data are typical of other FY93 data during Basin A intrusive activity and indicate the sensitivity of the OCP method to detect potential impacts and also the capability of available modeling tools to predict potential impacts.

4.7.4 Basin F Pesticide Impacts

As previously discussed, a comprehensive evaluation of the ambient impacts from Basin F cleanup operations and other remedial activities is performed by considering all CAQMMP and Basin F Remedial Monitoring Program data collected during the remedial and post-remedial periods. Some SVOC/OCP data have been presented in previous sections; however, this section will provide a more comprehensive comparative analysis.

Tables 4.7-5 and 4.7-6 provide a comparison between Basin F SVOC/OCP data during remediation (Phase 1) and the most recent post-remediation period (Phase 7). Intermediate phases are provided in previous CMP/CAQMMP Annual Reports. Several perimeter sites and interior site AQ8 are also included in this comparison. It is apparent that measurements of pesticides in the remediated basin area have been significantly reduced during this post-remedial period (by several orders of magnitude); also see Figure 4.7-2, which shows bar graphs for several pesticides over the remedial and post-remedial periods. Perimeter site measurements have remained near constant levels, indicating that the contaminants are confined to selected interior locations (i.e., Basin F, Basin A). Of interest is the increase in pesticide concentrations at AQ8 during FY93 intrusive activities. Nevertheless, these levels are well below the high

Table 4.7-5 Summary of Average Organochlorine Pesticide Results for Phases 1, 2 Stage 1, and 7 ($\mu g/m^3$)

Site	Phases	Aldrin	Chlordane	Dieldrin	Endrin	Isodrin	PPDDE	PPDDT
AQ3	Phase 1	0.0053	0.0003	0.0022	0.0013	0.0005	ND	0.0004
	Phase 2 Stage 1	ND	0.0003	0.0004	0.0003	ND	ND	0.0003
	Phase 7	ND	0.0002	0.0002	ND	ND	ND	0.0002
AQ5	Phase 1	0.0013	0.0003	0.0013	0.0009	0.0003	0.0004	0.0006
	Phase 2 Stage 1	ND	0.0003	0.0003	ND	ND	ND	ND
	Phase 7	ND	0.0002	0.0002	ND	ND	ND	ND
AQ8	Phase 1	ND	ND	ND	ND	ND	0.0390	ND
	Phase 2 Stage 1	*	*	*	*	*	*	*
	Phase 7	0.0003	0.0041	0.0046	0.0008	0.0002	0.0002	0.0003
BF1/FC1	Phase 1	0.1913	ND	0.1408	0.0197	0.0076	ND	ND
	Phase 2 Stage 1	0.0106	ND	0.0075	0.0041	0.0013	ND	ND
	Phase 7	0.0002	0.0003	0.0007	0.0002	ND	ND	ND
BF2/FC2	Phase 1	0.4579	ND	0.2768	0.1209	0.0424	ND	ND
	Phase 2 Stage 1	0.0154	ND	0.0107	0.0044	0.0010	ND	ND
	Phase 7	0.0002	0.0003	0.0020	0.0002	ND	ND	0.0002
BF3/FC3	Phase 1	0.0662	ND	0.0808	0.0250	0.0030	ND	ND
	Phase 2 Stage 1	0.0026	ND	0.0032	0.0017	0.0007	ND	ND
	Phase 7	0.0002	0.0004	0.0021	0.0002	ND	ND	ND
BF4/FC4	Phase 1	0.0499	ND	0.0477	0.0234	0.0030	ND	ND
	Phase 2 Stage 1	0.0034	ND	0.0027	0.0014	0.0007	ND	ND
	Phase 7	ND	0.0002	0.0005	0.0002	ND	ND	ND
BF5	Phase 1	0.0221	ND	0.0193	0.0096	0.0011	ND	ND
	Phase 2 Stage 1	0.0010	ND	0.0010	0.0008	ND	ND	ND
	Phase 7	*	*	*	*	*	*	*

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Table 4.7-5 Summary of Average Organochlorine Pesticide Results for Phases 1, 2 Stage 1, and 7 ($\mu g/m^3$)

Site	Phases	Aldrin	Chlordane	Dieldrin	Endrin	Isodrin	PPDDE	PPDDT
FC5	Phase 1	*	*	*	*	*	*	*
	Phase 2 Stage 1	*	*	*	*	*	*	*
	Phase 7	0.0002	0.0003	0.0008	0.0002	ND	ND	ND

* Samples not collected at this site.
ND Not detected.
$\mu g/m^3$ Micrograms per cubic meter

Note: Phase 1 is from March 22 to December 12, 1988.
Phase 2, Stage 1 is from December 13, 1988 to February 15, 1989.
Phase 7 is from October 1, 1992 to September 30, 1993.

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Table 4.7-6 Summary of 24-Hour Maximum Organochlorine Pesticide Results for Phases 1, 2 Stage 1, and 7 ($\mu g/m^3$)

Site	Phases	Aldrin	Chlordane	Dieldrin	Endrin	Isodrin	PPDDE	PPDDT
AQ3	Phase 1	0.0290	0.0005	0.0061	0.0041	0.0024	ND	0.0012
	Phase 2 Stage 1	ND	0.0004	0.0009	0.0004	ND	ND	0.0006
	Phase 7	ND	0.0012	0.0012	ND	ND	ND	0.0005
AQ5	Phase 1	0.0095	0.0008	0.0074	0.0046	0.0008	0.0023	0.0050
	Phase 2 Stage 1	ND	0.0004	0.0006	ND	ND	ND	ND
	Phase 7	ND	0.0007	0.0007	ND	ND	ND	ND
AQ8	Phase 1	ND	ND	ND	ND	ND	0.0390	ND
	Phase 2 Stage 1	*	*	*	*	*	*	*
	Phase 7	0.0018	0.0360	0.0430	0.0052	0.0012	0.0006	0.0024
BF1/FC1	Phase 1	0.8366	ND	0.4904	0.2497	0.0604	ND	ND
	Phase 2 Stage 1	0.0830	ND	0.0361	0.0223	0.0114	ND	ND
	Phase 7	0.0017	0.0016	0.0068	0.0004	ND	ND	ND
BF2/FC2	Phase 1	2.8290	ND	2.2960	0.9020	0.8160	ND	ND
	Phase 2 Stage 1	0.1244	ND	0.0355	0.0147	0.0100	ND	ND
	Phase 7	0.0023	0.0021	0.0190	0.0013	ND	ND	0.0004
BF3/FC3	Phase 1	0.4288	ND	1.6568	0.5458	0.0226	ND	ND
	Phase 2 Stage 1	0.0234	ND	0.0130	0.0061	0.0034	ND	ND
	Phase 7	0.0006	0.0016	0.0120	0.0007	ND	ND	ND
BF4/FC4	Phase 1	0.3478	ND	0.3265	0.2591	0.1136	ND	ND
	Phase 2 Stage 1	0.0321	ND	0.0099	0.0042	0.0078	ND	ND
	Phase 7	ND	0.0007	0.0015	ND	ND	ND	DN
BF5	Phase 1	0.1723	ND	0.0499	0.0275	0.0080	ND	ND
	Phase 2 Stage 1	0.0080	ND	0.0030	0.0010	ND	ND	ND
	Phase 7	*	*	*	*	*	*	*

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Table 4.7-6 Summary of 24-Hour Maximum Organochlorine Pesticide Results for Phases 1, 2 Stage 1, and 7 ($\mu g/m^3$)

Site	Phases	Aldrin	Chlordane	Dieldrin	Endrin	Isodrin	PPDDE	PPDDT
AQ3	Phase 1	0.0290	0.0005	0.0061	0.0041	0.0024	ND	0.0012
	Phase 2 Stage 1	ND	0.0004	0.0009	0.0004	ND	ND	0.0006
	Phase 7	ND	0.0012	0.0012	ND	ND	ND	0.0005
AQ5	Phase 1	0.0095	0.0008	0.0074	0.0046	0.0008	0.0023	0.0050
	Phase 2 Stage 1	ND	0.0004	0.0006	ND	ND	ND	ND
	Phase 7	ND	0.0007	0.0007	ND	ND	ND	ND
AQ8	Phase 1	ND	ND	ND	ND	ND	0.0390	ND
	Phase 2 Stage 1	*	*	*	*	*	*	*
	Phase 7	0.0018	0.0360	0.0430	0.0052	0.0012	0.0006	0.0024
BF1/FC1	Phase 1	0.8366	ND	0.4904	0.2497	0.0604	ND	ND
	Phase 2 Stage 1	0.0830	ND	0.0361	0.0223	0.0114	ND	ND
	Phase 7	0.0017	0.0016	0.0068	0.0004	ND	ND	ND
BF2/FC2	Phase 1	2.8290	ND	2.2960	0.9020	0.8160	ND	ND
	Phase 2 Stage 1	0.1244	ND	0.0355	0.0147	0.0100	ND	ND
	Phase 7	0.0023	0.0021	0.0190	0.0013	ND	ND	0.0004
BF3/FC3	Phase 1	0.4288	ND	1.6568	0.5458	0.0226	ND	ND
	Phase 2 Stage 1	0.0234	ND	0.0130	0.0061	0.0034	ND	ND
	Phase 7	0.0006	0.0016	0.0120	0.0007	ND	ND	ND
BF4/FC4	Phase 1	0.3478	ND	0.3265	0.2591	0.1136	ND	ND
	Phase 2 Stage 1	0.0321	ND	0.0099	0.0042	0.0078	ND	ND
	Phase 7	ND	0.0007	0.0015	ND	ND	ND	DN
BF5	Phase 1	0.1723	ND	0.0499	0.0275	0.0080	ND	ND
	Phase 2 Stage 1	0.0080	ND	0.0030	0.0010	ND	ND	ND
	Phase 7	*	*	*	*	*	*	*

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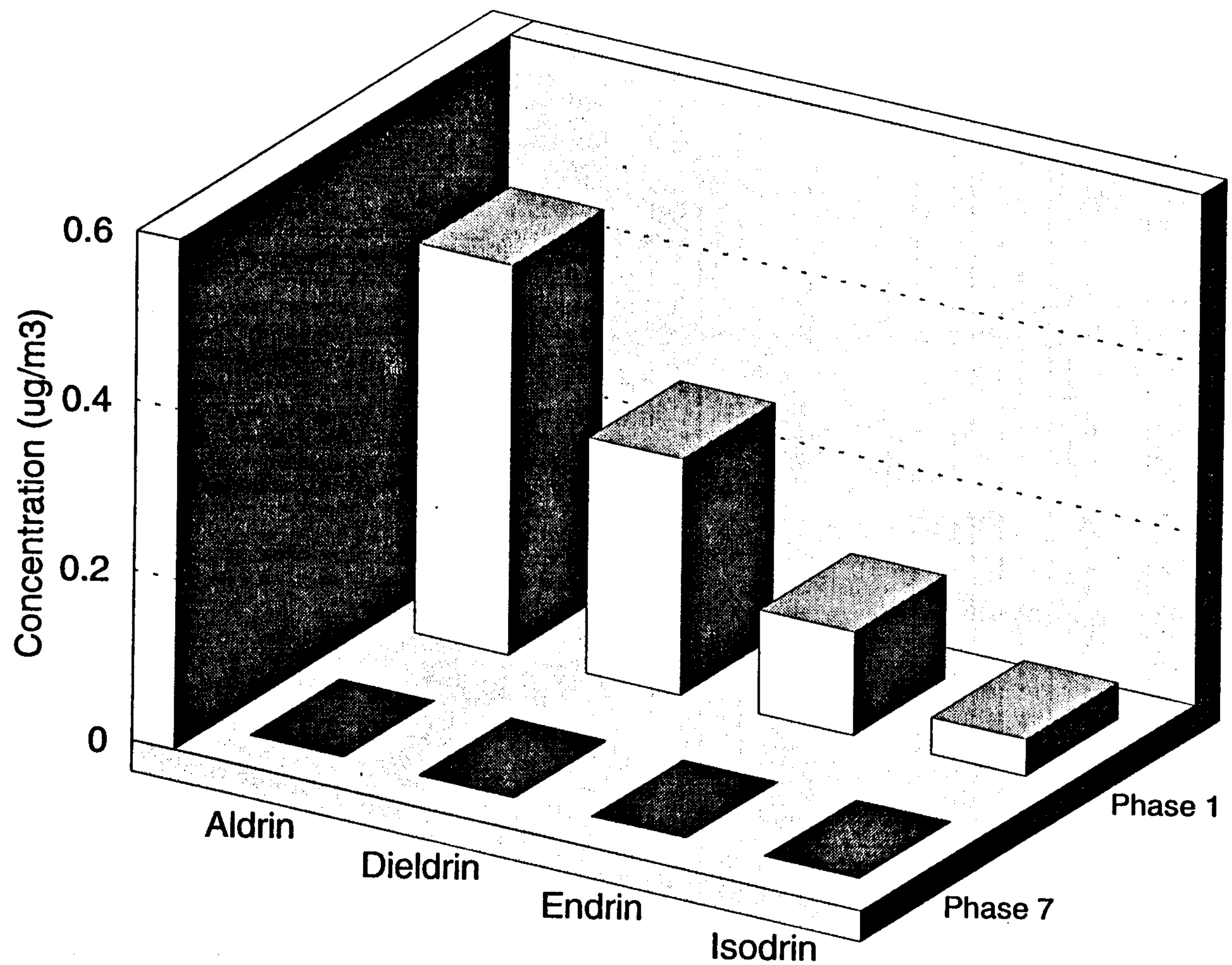

Prepared for:

U.S. Army Program Manager
for Rocky Mountain Arsenal

Figure 4.7–2

Average OCP Concentrations
at FC2

Rocky Mountain Arsenal
Prepared by: Ebasco Services Incorporated

concentrations achieved during active Basin F remediation. One exception is that higher concentrations of chlordane have been measured during Phase 7 than in previous post-remedial phases, indicating the potential for pesticide releases during continuing remediation activities at certain specified areas.

4.7.5 Summary of SVOC/OCP Results

Table 4.7-7 shows the locations of both maximum long-term (annual) average and maximum short-term (24-hour) SVOC/OCP concentrations for the combined CMP/CAQMMP and Basin F data analyses results for the phases of remediation. It is noted that almost all of the highest concentrations occurred in the initial remediation phase; however, the 24-hour maximum concentration of chlordane at AQ8 in FY93 (Phase 7) matched the highest 24-hour level in Phase 2 (Step 1) at BF2. Also, highest concentrations occurred most often at station BF2, directly downwind from Basin F.

As in the case of VOCs, the CAQMMP awaits the promulgation of CDH air toxic standards in order to provide a more definitive evaluation of RMA OCP/SVOC monitored data. In summary, Basin F appeared to be a potential source of several SVOC and OCP compounds measured under the CAQMMP and Basin F monitoring programs. In particular, these included aldrin, endrin, and dieldrin. Highest levels were clustered around Basin F. Monitoring station BF2 on the northeast perimeter of the basin measured the highest concentrations for most compounds. Pesticide levels at all RMA sites, and in particular Basin F sites, decreased significantly during the Basin F post-remedial period including FY93, although low levels of some pesticide compounds continued to be measured.

4.8 AIR STRIPPER OFF-GAS TESTING

This section provides the results of the CAQMMP air stripper off-gas testing at the A-Neck groundwater treatment facility. The air stripper system is located in the south room of the A-Neck groundwater treatment building. Water supplied to the air stripper for treatment is obtained from a groundwater extraction well located near the Basin F area. Off-gas samples were obtained

Table 4.7-7 Maximum Average Long-term and Short-term Semivolatile Organic Compound Concentrations

SVOC	Maximum Long-term* Average ($\mu g/m^3$)	Location	Phase	Maximum Short-term Concentration ($\mu g/m^3$)	Location	Phase
Aldrin	0.5263	BF2	P1	2.8290	BF2	P1
Chlordane	0.0071	BF2	P2-S1	0.0360 0.0360	BF2 AQ8	P2-S1 P7
Dieldrin	0.3971	CMP/BF2	P1	2.2960	BF2	P1
Endrin	0.1343	CMP/BF2	P1	1.0954	BF2	P1
Isodrin	0.1122	CMP/BF2	P1	0.9450	BF2	P1
PPDDE	0.0390	AQ8	P1	0.0390	BF2	P1
PPDDT	0.0350	CMP/BF2	P1	0.0585	CMP/BF2	P1
Atrazine	ND	NA	NA	ND	NA	NA
Malathion	ND	NA	NA	ND	NA	NA
Parathion	0.1311	CMP/BF2	P1	0.2099	CMP/BF2	P1
Supona	ND	NA	NA	ND	NA	NA

* Several maximum long-term averages provided in this table represent limited sampling from the high event programs.
$\mu g/m^3$ Micrograms per cubic meter

Legend:
- PPDDE = Dichlorodiphenylethane
- PPDDT = Dichlorodiphenyltrichloroethane
- P1 = Phase 1
- P2-S1 = Phase 2-Stage 1
- P7 = Phase 7
- NA = Not applicable
- ND = Not detected

at three locations: upstream, prior to carbon adsorption; midstream, after treatment in the first carbon unit; and downstream, following the second carbon unit and exhaust blower. The carbon adsorption units are filled with granular activated carbon and are designed for vapor phase contaminant reduction in air flow streams. Sorbent tubes and Tedlar bags were used for sample gas collection at the three off-gas sample ports. Background concentrations were determined by collection of ambient air in Tedlar bags and sorbent tubes at a position outside the building. All samples collected in Tedlar bags were immediately analyzed on site using OVA and OVM direct-reading instruments. Sorbent tube samples were shipped to the laboratory for analysis.

In each sampling event, sorbent tube samples were aerated with air stripper off gas for approximately 80 minutes. A volume of 10 liters of off gas was typically sampled using the tube sets. The samples obtained in Tedlar bags were collected in a period of approximately 3 minutes. A series of three bag samples was collected during the tube aeration periods. During weekly events, the normal testing routine entailed the collection of bag samples at the three ports and exterior position, plus sorbent tube samples at the midstream port (port B) using front and middle Tenax tubes followed by an XAD (adsorbent resin for SVOC sampling) tube in series. During monthly events, the normal testing routine entailed collection of bag samples at the same locations as in weekly events plus sorbent tube samples outside the air stripper building and at the upstream (port A), midstream (port B), and downstream (port C) ports using Tenax, Tenax back-up, and XAD tubes in series. Monthly events also included a collocated tube sample set at the midstream port and a set of Tenax and XAD field blanks.

4.8.1 Real-time Sampling Results

A synopsis of sampling efforts is shown in Table 4.8-1, including the calendar week, test date, and type of test performed. A listing of the real-time OVA and OVM readings for each event is shown in Table 4.8-2. For each port position data point, a set of three consecutive off-gas samples were collected using the Tedlar bags to obtain the ambient air background compensated average. A summary of the readings is presented in Table 4.8-3.

Table 4.8-1 Synopsis of Air Stripper Off-Gas Testing Program

Week of	Test Date	Testing Performed
10/04/92	10/08/92	Real-time only[1]
10/11/92	10/15/92	Real-time only[1]
10/18/92	10/21/92	Real-time only[1]
10/25/92	10/29/92	Real-time only[1]
11/01/92	11/05/92	Real-time only[1]
11/08/92	11/12/92	Real-time only[1]
11/15/92	11/17/9	Real-time only[1]
11/22/92	11/27/92	Real-time only[1]
11/30/92	12/02/92	Real-time only[1]
12/06/92	12/11/92	Real-time only[1]
12/13/92	12/17/92	Weekly
12/20/92	12/23/92	Monthly
12/29/92	12/29/92	Weekly
01/03/93	01/06/93	Weekly
01/10/93	01/15/93	Weekly
01/17/93	01/21/93	Monthly
01/24/93	01/28/93	Weekly
01/31/93	02/03/93	Weekly
02/07/93	02/09/93	Weekly
02/14/93	02/19/93	Monthly
02/21/93	02/26/93	Weekly
02/28/93	03/05/93	Weekly
03/07/93	03/10/93	Weekly
03/14/93	03/16/93	Weekly
03/21/93	03/23/93	Monthly
03/28/93	04/02/93	Weekly
04/04/93	04/08/93	Weekly
04/11/93	04/15/93	Weekly
04/18/93	04/23/93	Monthly

Table 4.8-1 Synopsis of Air Stripper Off-Gas Testing Program

Week of	Test Date	Testing Performed
04/25/93	04/28/93	Weekly
05/02/93	05/04/93	Weekly
05/09/93	05/11/93	Weekly
05/16/93	05/19/93	Weekly
05/23/93	05/27/93	Monthly
05/30/93	06/03/93	Weekly
06/06/93	06/08/93	Weekly
06/13/93 to 07/11/93	NA	None[2]
07/18/93	07/20/93	Monthly
07/25/93 to 09/29/93	NA	None[2]

NA - Not Applicable
1 - Sampling media from laboratory not available
2 - Air stripper inoperative during these periods

Table 4.8-2 FY93 Air Stripper Real-Time Testing Results

Sample Date	OVA (ppm)				OVM (ppm)			
	Ambient	Downstream*	Midstream*	Upstream*	Ambient	Downstream*	Midstream*	Upstream*
10-08-92	1.4	0.2	1.2	NS	0.1	0.0	0.0	NS
10-15-92	0.3	0.1	0.9	2.7	0.2	0.0	0.1	0.1
10-21-92	1.2	1.9	3.7	3.7	0.2	0.0	0.1	0.1
10-29-92	1.1	4.1	6.1	6.2	0.0	0.1	0.0	0.0
11-05-92	1.1	1.2	2.8	4.2	0.0	0.0	0.0	0.1
11-12-92	0.9	2.0	2.7	5.9	0.0	0.0	0.0	0.0
11-17-92	1.3	2.7	5.1	12.3	0.0	0.2	0.2	0.3
11-27-92	0.5	0.7	1.2	2.0	0.3	0.0	0.1	0.2
12-02-92	3.9	3.3	29.1	33.8	0.0	0.0	0.0	0.0
12-11-92	1.6	3.1	5.9	6.1	0.2	0.0	0.1	0.1
12-17-92	0.3	3.3	5.5	5.6	0.0	0.6	0.8	1.2
12-23-92	1.5	3.9	5.2	5.1	0.0	0.2	0.3	0.4
12-29-92	2.2	2.9	2.5	3.2	0.0	0.1	0.1	0.2
01-06-93	0.8	4.7	4.9	5.2	0.0	0.2	0.3	0.5
01-15-93	2.0	4.8	5.4	5.2	0.0	0.0	0.4	0.3
01-21-93	1.9	4.3	4.8	4.7	0.0	0.0	0.0	0.0
01-28-93	1.4	4.3	4.7	0.6	0.0	0.2	0.2	0.3
02-03-93	1.8	4.1	4.3	5.0	0.0	0.0	0.0	0.1
02-09-93	2.2	4.0	4.1	4.9	0.0	0.0	0.0	0.3
02-19-93	1.8	4.3	3.6	5.6	0.0	0.0	0.0	0.0

* - Note: these results are background compensated (i.e., Result-Ambient reading)

OVA - Organic Vapor Analyser
OVM - Organic Vapor Meter
ppm - Parts per million

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Table 4.8-2 FY93 Air Stripper Real-Time Testing Results

	OVA (ppm)				OVM (ppm)			
Sample Date	Ambient	Downstream*	Midstream*	Upstream*	Ambient	Downstream*	Midstream*	Upstream*
02-26-93	0.0	3.2	3.4	5.7	0.0	0.0	0.0	0.1
03-05-93	1.9	4.0	4.6	7.0	0.0	0.0	0.0	0.0
03-10-93	1.6	0.3	0.3	6.0	0.0	0.0	0.0	0.0
03-16-93	1.7	0.2	0.2	6.1	0.0	0.0	0.0	0.0
03-23-93	1.9	0.3	0.3	5.8	0.0	0.0	0.0	0.0
04-02-93	1.8	0.4	0.9	5.4	0.0	0.0	0.0	0.0
04-08-93	2.0	0.3	1.6	4.6	0.0	0.0	0.0	0.0
04-15-93	2.0	0.3	3.1	5.4	0.0	0.0	0.0	0.0
04-23-93	0.9	0.1	3.1	4.7	0.0	0.0	0.0	0.0
04-28-93	1.8	0.0	3.6	4.6	0.0	0.0	0.0	0.0
05-05-93	1.7	0.2	3.5	2.9	0.0	0.0	0.0	0.0
05-11-93	1.9	0.1	2.6	10.1	0.0	0.0	0.0	0.0
05-19-93	1.8	0.4	2.9	10.6	0.0	0.0	0.0	0.0
05-27-93	2.0	1.0	9.1	13.0	0.0	0.0	0.0	0.0
06-03-93	0.9	1.6	11.1	8.7	0.0	0.0	0.0	0.0
06-08-93	1.1	1.7	11.9	15.6	0.0	0.0	0.0	0.0
07-20-93	2.0	1.0	9.3	9.8	0.0	0.0	0.0	0.0

* - Note: these results are background compensated (i.e., Result-Ambient reading)

OVA - Organic Vapor Analyser
OVM - Organic Vapor Meter
ppm - Parts per million

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Table 4.8-3 Summary of FY93 Air Stripper Real-Time Testing Results

Location	OVA Average (ppm)	OVA Maximum (ppm)	OVM Average (ppm)	OVM Maximum (ppm)
Ambient	1.5	3.9	0.03	0.3
Upstream*	6.9	33.8	0.12	1.2
Midstream*	4.7	29.1	0.07	0.8
Downstream*	2.0	4.8	0.04	0.6

* Note: These readings are background compensated (i.e. Result-Ambient)

OVA - Organic Vapor Analyzer
OVM - Organic Vapor Meter
ppm - Parts per million

As indicated in Table 4.8-3, the overall direct reading instrument averages indicate that concentrations measured at the midstream and downstream ports are consistently lower than those measured at the upstream port. The trend of decreasing concentrations measured from upstream, to midstream, and then downstream ports is consistent for both OVA and OVM average and maximum values. The average VOC reductions from upstream to downstream port positions as indicated by the OVA and OVM, were 71 percent and 67 percent, respectively. The maximum upstream and midstream OVA readings were 33.8 and 29.1 ppm, respectively and were observed on December 2, 1992. The high OVA readings on that date may be associated with the use of air stripper descaling agent in the raw feed water. On December 2, 1992, the sampling technicians observed a citrus type odor present near the exterior doors of the air stripper room in the area where the descaling solution tank is located.

4.8.2 Air Stripper Sorbent Tube Sampling Results

A synopsis of the FY93 air stripper sampling events using sorbent tubes is presented in Table 4.8-4, and results from analysis of the Tenax and XAD tubes are summarized in Table 4.8-5. In general, the air stripper sample analyses were performed using the same methods as in the CAQMMP ambient air VOC and SVOC sampling. The complete data set and results for field blanks are provided in Appendix E. As seen in the data listing, results for many compounds were less than the CRL at all sampling ports. Those compounds detected most frequently include methylene chloride, chloroform, toluene, and benzene. Average values for the summarized analytical data indicate that 1,2-dichloroethene, methylene chloride, chloroform, and toluene were detected at the upstream, midstream, and downstream ports at concentrations greater than 5 $\mu g/m^3$. Analysis of the field blanks indicate results which were generally less than the CRLs for the various target compounds.

Methylene chloride, a non-certified compound, and chloroform were both frequently detected at concentrations above the CRLs and were significantly higher than the other target compounds. Many reported values for these two compounds were based upon post-analytical laboratory estimates as discussed in Section 4.6. The highest average methylene chloride concentration

Table 4.8-4 Synopsis of FY93 Air Stripper Sorbent Tube Sampling

Location	VOC Samples Collected	SVOC Samples Collected
Upstream	7	7
Midstream	26	21
Downstream	7	7
Ambient	5	5
Midstream duplicate	7	7

VOC - Volatile Organic Compound
SVOC - Semivolatile Organic Compound

Table 4.8-5 Summary of FY93 Air Stripper Volatile Organic Compound Concentrations (μg/m^3)

Location		111TCE	112TCE	11DCLE	12DCLE	12DCE	BCHPD	C6H6	CCL4	CH2CL2	CHCL3
Upstream	Average	< 2.3	< 3.6	2.6	7.6	< 1.2	6.3	5.1	< 1.8	656.7	3226.0
	Maximum	3.6	< 3.6	6.0	15.0	< 1.2	14.0	9.2	< 1.8	2410.0	5280.0
Midstream	Average	2.4	< 3.6	2.6	8.1	< 1.2	2.7	2.6	3.8	282.3	2321.0
	Maximum	9.6	< 3.6	8.9	46.0	< 1.2	52.0	20.0	73.0	1368.0	6942.0
Midstream Duplicate	Average	1.8	< 3.6	2.0	3.9	< 1.2	2.6	2.5	< 1.8	351.7	1729.0
	Maximum	4.1	< 3.6	5.0	12.0	< 1.2	8.8	6.4	< 1.8	545.0	5020.0
Downstream	Average	3.0	< 3.6	3.1	6.1	< 1.2	< 1.2	< 1.6	< 1.8	1088.7	3119.0
	Maximum	11.0	< 3.6	13.0	39.0	< 1.2	< 1.2	3.2	< 1.8	5010.0	15830.0
Ambient	Average	2.3	< 3.6	< 1.2	< 1.2	< 1.2	< 1.2	4.5	< 1.8	477.4	< 1.2
	Maximum	7.1	< 3.6	< 1.2	< 1.2	< 1.2	< 1.2	10.8	< 1.8	2300.0	3.2

		CLC6H5	DBCP	DCPD	DMDS	ETC6H5	MEC6H5	MIBK	TCLEE	TRCLE	XYLENES
Upstream	Average	< 1.3	< 10.0	< 8.9	< 4.7	< 3.2	5.5	< 16.0	5.6	4.2	< 15.0
	Maximum	< 1.3	< 10.0	< 8.9	< 4.7	< 3.2	13.0	< 16.0	20.0	8.4	< 15.0
Midstream	Average	< 1.3	< 10.0	< 8.9	< 4.7	< 3.2	14.5	< 16.0	2.8	< 1.3	< 15.0
	Maximum	< 1.3	< 10.0	< 8.9	< 4.7	6.0	50.0	< 16.0	44.0	< 1.3	26.0
Midstream Duplicate	Average	< 1.3	< 10.0	< 8.9	< 4.7	< 3.2	4.4	< 16.0	< 1.3	< 1.3	< 15.0
	Maximum	< 1.3	< 10.0	< 8.9	< 4.7	< 3.2	7.3	< 16.0	< 1.3	3.1	< 15.0
Downstream	Average	< 1.3	< 10.0	< 8.9	< 4.7	< 3.2	5.1	< 16.0	< 1.3	< 1.3	< 15.0
	Maximum	< 1.3	< 10.0	< 8.9	< 4.7	< 3.2	7.9	< 16.0	< 1.3	< 1.3	< 15.0
Ambient	Average	< 1.3	< 10.0	< 8.9	< 4.7	< 3.2	4.9	< 16.0	< 1.3	< 1.3	< 15.0
	Maximum	< 1.3	< 10.0	< 8.9	< 4.7	< 3.2	12.4	< 16.0	< 1.3	< 1.3	< 15.0

111TCE - 1,1,1-Trichloroethane
112TCE - 1,1,2-Trichloroethane
11DCLE - 1,1-Dichloroethane
12DCLE - 1,2-Dichloroethane
12DCE - trans-1,2-Dichloroethene
BCHPD - Bicycloheptadiene
C6H6 - Benzene
CCL4 - Carbon Tetrachloride
CH2CL2 - Methylene Chloride
CHCL3 - Chloroform
CLC6H5 - Chlorobenzene
DBCP - Dibromochloropropane
DCPD - Dicyclopentadiene
DMDS - Dimethyldisulfide
ETC6H5 - Ethylbenzene
MEC6H5 - Toluene
MIBK - Methyl Isobutyl Ketone
TCLEE - Tetrachloroethene
TRCLE - Trichloroethene
XYLENES - Total Xylenes

< ### Indicates concentration less than the lower certified reporting limit
μg/m^3 Micrograms per meter

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was 1088.7 µg/m³ at the downstream port. Upstream and midstream methylene chloride average concentrations were 656.7 and 282.3 µg/m³, respectively. The average ambient air background concentration for methylene chloride was 477.4 µg/m³. However, this was based on a 1-day (December 23, 1992) very high measurement; all other measurements were less than 3 µg/m³; in addition, the field blank on this day indicated a high level of methylene chloride, making the sample suspect.

Average chloroform concentrations were the highest overall among all compounds at each sampling port location. The upstream, midstream, and downstream chloroform average concentrations were 3226.0, 2321.0, and 3119.0 µg/m³, respectively. Results of the blank sample analyses indicate values less than the lower CRL. Average ambient air background concentrations for chloroform were also less than the lower CRL. It should also be noted that the concentrations measured for all stripper analytes represent a very small sample volume for a short period (i.e., 80 minutes), and cannot be directly compared to the 24-hour measurements collected under the routine CAQMMP VOC sampling program.

Evaluation of the analytical results with respect to performance of the two carbon adsorption units indicate progressive reduction of off-gas concentrations from the first to the second unit in the case of 1,2-dichloroethene, bicycloheptadiene, benzene, carbon tetrachloride, toluene, and tetrachloroethene; exceptions to this sequence were methylene chloride and chloroform, suggesting possible concerns in system performance for these compounds, although laboratory analysis may also be a factor; CAQMMP will further investigate these results. Average results for 1,1,2-trichloroethane, trans-1,2-dichloroethene, chlorobenzene, dibromochloropropane, dicyclopentadiene, dimethyldisulfide, ethylbenzene, methyl isobutyl ketone, and total xylenes were less than the lower CRL for samples collected at all sampling locations. Analytical results for duplicate samples indicated general agreement with primary sample values with the exception of 1,2-dichloroethane and toluene. Possible reasons for the nonconformance of the paired sample results for these two compounds are not readily apparent.

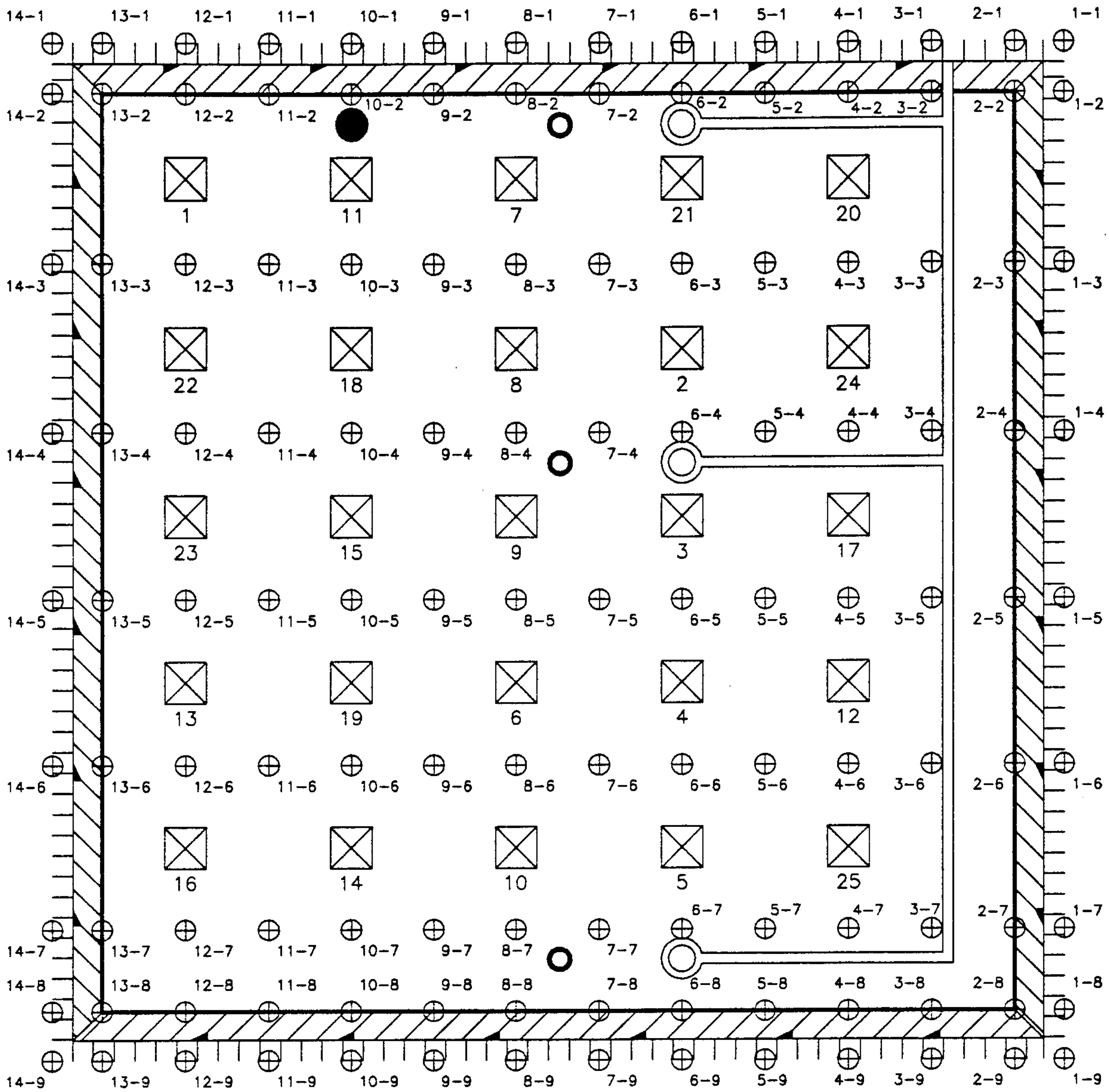
Results of the XAD tube analyses indicated that concentrations for all SVOC target compounds were less than the lower CRLs, or detection limits, for noncertified compounds. Results of field blank analyses indicated no detections.

4.9 REAL-TIME CAP AND VENT MONITORING

4.9.1 Program Description

The FY93 CAQMMP included periodic monitoring of the restored Basin F floor, Basin F waste pile cap surface, Basin F waste pile vents, and vents associated with Basin F liquid storage at Pond A and the three holding tanks. Both real-time monitoring and VOC sampling with sorbent tubes were performed. The stated testing schedule entailed seasonal real-time monitoring and quarterly VOC sampling with the Tenax and Tenax/Charcoal tubes. The VOC sampling was actually performed in conjunction with real-time monitoring during periods when prevailing atmospheric conditions were conducive to the development of positive vent outflows. The real-time monitoring and sampling were conducted to characterize emissions of the sources and aid in assessing their possible impact on ambient air quality. Real-time monitoring was performed using portable instrumentation which included an OVA, an OVM, an ammonia meter, and a hydrogen sulfide meter (see Sections 3.3.4, 3.3.8, and 3.3.9 for descriptions of these instruments).

During construction of the Basin F waste pile, 25 passive off-gas release vents were installed through the liner to relieve potential air pressure gradients from recurring atmospheric pressure changes and from internal vaporization of contaminants. The vents are spaced in an irregular grid across the waste pile, as indicated in Figure 4.9-1, and the vents are numbered randomly. The height of each vent varies with the depth of the waste pile cap and ranges from 1- to 3-ft above ground. The vent pipes are 6 inches in diameter and terminate in an elbow facing the ground. The waste pile vents penetrate an average of 1.5 feet through the soil cover to the plastic liner cap. The vents allow passive emission of soil gases that have passed through the pile material and accumulated beneath the upper liner. Vent emission flow rates are typically negligible due to the shallow depths of the vent pipes and the relative absence of void spaces or active offgassing conditions within the compacted waste pile. Offgassing rates are also



LEGEND

5 ☒ Vent with Existing Vent Number

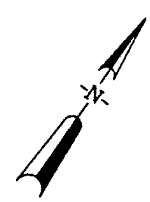
⊕ Sand Bags

● Baseplate Standpipe

○ Detection Sump and Baseplate Standpipe

◎ Leachate Collection Sump and Baseplate Standpipe

═ Transfer Pipe



NOT TO SCALE

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U.S. Army Program Manager
for Rocky Mountain Arsenal

Figure 4.9-1

Waste Pile Vent Locations

Rocky Mountain Arsenal
Prepared by: Ebasco Services Incorporated

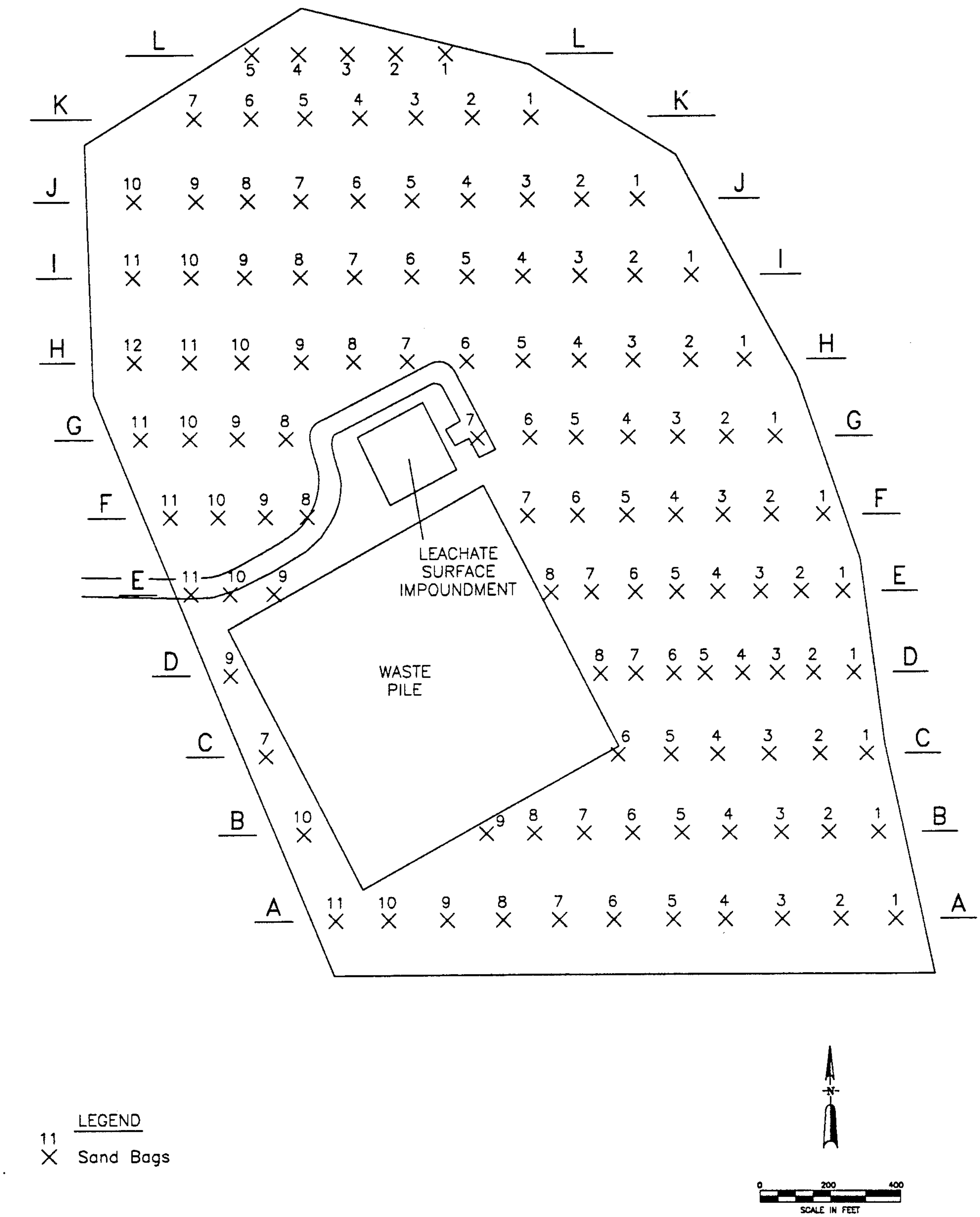
influenced by barometric pressure trends, with prolonged periods of high pressure being conducive for the accumulation of ambient air beneath the vents within the upper portions of the waste pile. A subsequent decrease in barometric pressure will enhance the brief outflow of accumulated ambient air and soil gas. Vent flow rate tests have confirmed a typically neutral condition of vent flow. Therefore, emissions of volatiles and semivolatiles from the waste pile vents occur mainly as a result of passive diffusion from each vent to the atmosphere.

Real-time monitoring of the waste pile vents took place four times during the FY93 period. The readings were taken about 1 inch below the vent opening on the downwind side, during periods when winds were light (less than 10 mph) and atmospheric pressure was dropping. Readings were taken with the four real-time instruments over an approximate 30-second interval.

Real-time readings of the waste pile cap surface were also taken. The four real-time instruments were fitted with an extension tube ending in a small funnel. The technician traversed the waste pile cap in a predetermined pattern and collected representative readings at a total of 126 marked locations regularly spaced across the waste pile. These locations are shown in Figure 4.9-1. The sample was drawn from approximately 1 inch above ground at each location, and real-time readings were recorded on field data sheets.

Similar readings were taken from the restored Basin F floor, which is covered with a clay and topsoil cap. The Basin F floor readings were taken at 115 regularly spaced locations marked by sandbags, as depicted in Figure 4.9-2. Weather conditions and the physical appearance of the floor during each sampling episode were recorded prior to commencement of sampling.

Pond A is a double-lined liquid storage pond located just north of Basin F. The pond is covered with a high density polyethylene cover and has four vents, one in the middle of each side of the pond. The vents are equipped with trip valves that open to allow emission of gases and close to prevent entrainment of air beneath the pond cover. As a result, the pond gases are emitted in short pulses. Sampling the pond vents required a sample duration that spanned several pulses



Prepared for:
U.S. Army Program Manager
for Rocky Mountain Arsenal

Figure 4.9-2
Basin F Floor Sampling Locations

Rocky Mountain Arsenal
Prepared by: Ebasco Services Incorporated

of the trip valve. Pond A vents were tested with the real-time instrument probe inlets held near the vent openings.

The three storage tanks for the Basin F liquid are located northeast of the basin floor and are covered by metal roofs with passive vents atop each tank. Real-time tank vapor readings were taken with the four real-time instruments. Extension tubes were utilized to allow the instruments to draw vent gas from the vent opening to the platform location.

VOCs were also sampled at the waste pile vents, Pond A, and the three storage tanks. As noted, the VOC sampling was performed in conjunction with real-time monitoring activities. The same type of Tenax front and Tenax/charcoal backup tubes that were used routinely for ambient air sampling were used for vent sampling. A flow rate of 85 standard cubic centimeters per minute (sccm) was used for sampling over a 60-minute period. For samples collected at the selected pond, tank, and waste pile vents, the Tenax tube inlets were monitored in approximately the same positions used for real-time monitoring. Both trip blanks and field blanks were submitted with the VOC samples for analysis.

4.9.2 Basin F and Waste Pile Cap Monitoring Results

Results of real-time monitoring performed on the February 26, March 20, June 15, and October 4, 1993 at the Basin F floor locations indicate no detections were obtained with the OVA, OVM, and NH_3 instruments. Results of the restored Basin F floor and waste pile cap ground surface testing are summarized in Table 4.9-1. The basin floor and waste pile cap appear to be negligible sources of air emissions according to the levels detected by the real-time monitoring instruments utilized in this sampling program. In 1993, all OVA and OVM readings taken on the cap were 0.0 ppm. Furthermore, only 1 out of 920 readings taken at the basin floor in 1993 was not 0.0 (OVM 0.01 ppm). These results are comparable to previous years' data. During those monitoring events, there were numerous trace level recordings of H_2S. The averaged H_2S readings ranged from 0.0005 to 0.002 ppm and the maximum readings ranged from 0.001 to 0.005 ppm.

Table 4.9-1 Summary of Basin F Floor and Waste Pile Cap Monitoring Results

		OVA (ppm)			OVM (ppm)			NH_3 (ppm)			H_2S (ppm)		
Date	Location	# Detects	Avg.	Max.	# Detects	Avg.	Max.	# Detects	Avg.	Max.	# Detects	Avg.	Max.
2/26/93	Restored Basin F Floor	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	58	0.0005	0.001
3/20/93	Restored Basin F Floor	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	45	0.0005	0.002
6/15/93	Restored Basin F Floor	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	115	0.002	0.003
10/4/93	Restored Basin F Floor	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	98	0.002	0.005
3/1/93	Basin F Waste Pile Cap	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	68	0.0009	0.004
3/20/93	Basin F Waste Pile Cap	0	0.0	0.0	0	0.0	0.0	4	0.04	2.0	56	0.0007	0.004
5/13/93	Basin F Waste Pile Cap	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	111	0.0011	0.002
10/1/93	Basin F Waste Pile Cap	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	81	0.0008	0.002

Note:
Restored Basin F Floor - 115 sample locations
Basin F Waste Pile Cap - 126 sample locations
OVA - Organic Vapor Analyzer
OVM - Organic Vapor Meter
NH_3 - Ammonia
H_2S - Hydrogen Sulfide
ppm - Parts per million

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Results of real-time waste pile cap monitoring that was performed March 1, March 20, May 13, and October 1, 1993 indicate no detections associated with the OVA and OVM instruments. Ammonia was detected at four locations on March 20, 1993 at an average concentration of 0.004 ppm. Hydrogen sulfide readings taken at various locations on the waste pile cap ranged from 0.007 to 0.011 ppm for averaged results and from 0.002 to 0.004 ppm for maximum readings.

4.9.3 Waste Pile Vent Monitoring Results

Results of real-time readings taken at the waste pile vents are presented in Table 4.9-2. During FY93, real-time readings of the vents were taken on February 1, March 23, August 4, and September 8, 1993. The highest annual average of the four readings, 21.8 ppm, was observed at Vent 1 during FY93. The maximum OVA reading for FY93, 54.0 ppm, was also observed at Vent 1 on August 4. Vents 1, 13, 16, 22, and 23 had the highest average OVA readings. The OVM, NH_3, and H_2S readings were substantially lower than those obtained with the OVA. OVM readings averaged 0.14 ppm in 1993 while H_2S readings averaged 0.017 ppm; and NH_3 results indicated no detections.

Real-time readings were also taken at the three main sump covers. OVA readings at the sumps were not substantially different from vent readings. The OVM, NH_3, and H_2S readings taken at the sumps were generally higher than those obtained at the vents.

During each quarterly monitoring event, the four waste pile vents with the highest OVA readings were sampled using VOC cartridges. In FY93, nine different vents were sampled, with vents 13 and 16 being sampled most frequently. Table 4.9-3 summarizes the results of this sampling. Chloroform was the most prevalent compound and was also measured at the highest levels. It was present in 5 of the 9 samples analyzed at levels that ranged from below detection at several vents to 5412 $\mu g/m^3$ at Vent 23. Methylene chloride and tetrachloroethene were also detected frequently. Methylene chloride concentrations ranged up to 106.5 $\mu g/m^3$ at Vent 8 and tetrachloroethene levels reached 250.0 $\mu g/m^3$ at Vent 23. Other analytes regularly detected

Table 4.9-2 Basin F Waste Pile Vent Real-Time Monitoring Results

	OVA (ppm)				OVM (ppm)				NH_3 (ppm)				H_2S (ppm)			
Vent	2/1/93	3/23/93	8/4/93	9/8/93	2/1/93	3/23/93	8/4/93	9/8/93	2/1/93	3/23/93	8/4/93	9/8/93	2/1/93	3/23/93	8/4/93	9/8/93
1	4.8	4.2	54.0	24.0	0.5	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.012	0.001	0.0	0.0
2	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.053	0.001	0.0	0.0
3	3.4	6.0	0.5	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.045	0.002	0.0	0.0
4	0.7	1.2	2.2	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.024	0.003	0.0	0.0
5	0.8	1.8	2.4	3.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.036	0.002	0.0	0.0
6	4.8	3.2	4.6	3.2	0.5	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.022	0.003	0.0	0.0
7	6.6	0.8	0.0	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.039	0.001	0.0	0.0
8	6.2	0.8	0.3	4.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.028	0.001	0.0	0.0
9	5.2	3.2	1.8	7.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.024	0.003	0.0	0.0
10	4.4	0.4	1.4	2.6	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.022	0.003	0.0	0.0
11	0.0	0.0	0.1	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.013	0.000	0.0	0.0
12	0.2	0.6	0.6	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.006	0.005	0.0	0.0
13	5.6	17.0	6.8	18.0	1.0	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.017	0.002	0.0	0.0
14	2.8	1.8	2.8	2.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.020	0.004	0.0	0.0
15	0.0	0.6	0.6	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.013	0.002	0.0	0.0
16	10.8	26.0	19.0	12.0	0.5	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.016	0.003	0.0	0.0
17	1.0	0.4	0.2	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.005	0.062	0.0	0.0
18	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.012	0.001	0.0	0.0
19	0.2	8.4	4.6	1.4	0.5	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.016	0.002	0.0	0.0
20	0.6	0.4	0.0	1.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.004	0.160	0.0	0.0
21	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.042	0.001	0.0	0.0
22	1.6	2.8	48.0	18.0	0.5	0.0	0.0	2.0	0.0	0.0	0.0	0.0	0.013	0.001	0.0	0.0
23	2.0	2.6	5.0	12.2	0.5	0.6	0.2	0.0	0.0	0.0	0.0	0.0	0.015	0.002	0.0	0.0
24	1.2	1.0	0.2	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.004	0.066	0.0	0.0
25	2.8	9.6	1.0	3.8	0.5	0.6	0.4	0.0	0.0	0.0	0.0	0.0	0.005	0.000	0.0	0.0
Sump 1	0.6	10.2	0.5	2.0	0.0	14.0	0.0	0.0	4.0	46.1	12.0	4.0	0.119	0.420	0.0	0.0
Sump 2	7.2	18.0	7.0	2.0	7.1	18.2	2.2	0.0	16.0	44.0	>150.0	0.0	0.330	1.300	0.0	0.0
Sump 3	2.8	14.2	6.4	18.0	2.5	16.8	0.4	10.0	2.0	> 60.0	10.0	9.0	0.046	2.100	0.0	0.0

> ### - Indicates concentration above instrument upper detection limit
OVA - Organic Vapor Analyzer
OVM - Organic Vapor Meter
NH_3 - Ammonia
H_2S - Hydrogen Sulfide
ppm - Parts per million

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Table 4.9-3 Summary of FY93 Waste Pile Vents Volatile Organic Compound Concentrations (μg/m^3)

		111TCE	112TCE	11DCLE	12DCLE	12DCE	BCHPD	C6H6	CCL4	CH2CL2	CHCL3
Vent 1	Average	< 4.5	< 7.1	< 2.4	< 2.4	< 2.4	< 2.4	< 3.1	< 3.5	43.2	2199.0
	Maximum	6.3	< 7.1	2.9	< 2.4	< 2.4	< 2.4	< 3.1	< 3.5	76.0	3618.0
Vent 5	Average	< 4.5	< 7.1	< 2.4	< 2.4	< 2.4	< 2.4	4.7	< 3.5	19.6	< 2.4
	Maximum	< 4.5	< 7.1	< 2.4	< 2.4	< 2.4	< 2.4	4.7	< 3.5	19.6	< 2.4
Vent 7	Average	< 4.5	< 7.1	< 2.4	< 2.4	< 2.4	< 2.4	5.0	< 3.5	76.7	< 2.4
	Maximum	< 4.5	< 7.1	< 2.4	< 2.4	< 2.4	< 2.4	5.0	< 3.5	76.7	< 2.4
Vent 8	Average	< 4.5	< 7.1	< 2.4	< 2.4	< 2.4	< 2.4	< 3.1	< 3.5	106.5	< 2.4
	Maximum	< 4.5	< 7.1	< 2.4	< 2.4	< 2.4	< 2.4	< 3.1	< 3.5	106.5	< 2.4
Vent 13	Average	< 4.5	< 7.1	< 2.4	< 2.4	< 2.4	13.0	< 3.1	< 3.5	41.8	2243.0
	Maximum	< 4.5	< 7.1	< 2.4	< 2.4	< 2.4	21.0	4.9	< 3.5	98.8	4200.0
Vent 16	Average	< 4.5	< 7.1	3.9	< 2.4	< 2.4	79.7	6.2	< 3.5	64.3	2668.0
	Maximum	7.7	< 7.1	9.4	< 2.4	< 2.4	180.0	8.6	< 3.5	98.0	5314.0
Vent 19	Average	< 4.5	< 7.1	< 2.4	< 2.4	< 2.4	< 2.4	13.9	< 3.5	28.3	< 2.4
	Maximum	< 4.5	< 7.1	< 2.4	< 2.4	< 2.4	< 2.4	13.9	< 3.5	28.3	< 2.4
Vent 22	Average	6.0	< 7.1	5.6	< 2.4	< 2.4	< 2.4	3.6	< 3.5	91.0	5150.0
	Maximum	9.8	< 7.1	6.0	< 2.4	< 2.4	2.7	5.6	< 3.5	99.0	5300.0
Vent 23	Average	< 4.5	< 7.1	6.9	4.0	< 2.4	21.0	< 3.1	< 3.5	50.0	5412.0
	Maximum	< 4.5	< 7.1	6.9	4.0	< 2.4	21.0	< 3.1	< 3.5	50.0	5412.0

< ### Indicates concentration less than the lower certified reporting level
μg/m^3 Micrograms per cubic meter

111TCE -	1,1,1-Trichloroethane	BCHPD -	Bicycloheptadiene
112TCE -	1,1,2-Trichloroethane	C6H6 -	Benzene
11DCLE -	1,1-Dichloroethane	CCL4 -	Carbon Tetrachloride
12DCLE -	1,2-Dichloroethane	CH2CL2 -	Methylene Chloride
12DCE -	trans-1,2-Dichloroethene	CHCL3 -	Chloroform

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Table 4.9-3 . Summary of FY93 Waste Pile Vents Volatile Organic Compound Concentrations (μg/m³)

		CLC6H5	DBCP	DCPD	DMDS	ETC6H5	MEC6H5	MIBK	TCLEE	TRCLE	XYLENES
Vent 1	Average	< 2.5	< 20.0	128.5	< 9.2	< 6.3	< 2.7	< 31.0	7.3	< 2.6	< 29.2
	Maximum	< 2.5	< 20.0	230.0	< 9.2	< 6.3	< 2.7	< 31.0	11.0	< 2.6	< 29.2
Vent 5	Average	< 2.5	< 20.0	< 17.5	< 9.2	< 6.3	< 2.7	< 31.0	< 2.5	< 2.6	< 29.2
	Maximum	< 2.5	< 20.0	< 17.5	< 9.2	< 6.3	< 2.7	< 31.0	< 2.5	< 2.6	< 29.2
Vent 7	Average	< 2.5	< 20.0	< 17.5	< 9.2	< 6.3	8.1	< 31.0	< 2.5	< 2.6	< 29.2
	Maximum	< 2.5	< 20.0	< 17.5	< 9.2	< 6.3	8.1	< 31.0	< 2.5	< 2.6	< 29.2
Vent 8	Average	< 2.5	< 20.0	< 17.5	< 9.2	< 6.3	4.6	< 31.0	< 2.5	< 2.6	< 29.2
	Maximum	< 2.5	< 20.0	< 17.5	< 9.2	< 6.3	4.6	< 31.0	< 2.5	< 2.6	< 29.2
Vent 13	Average	< 2.5	< 20.0	24.6	< 9.2	< 6.3	3.1	< 31.0	19.3	< 2.6	< 29.2
	Maximum	< 2.5	< 20.0	52.0	< 9.2	< 6.3	4.9	< 31.0	37.0	< 2.6	< 29.2
Vent 16	Average	< 2.5	< 20.0	< 17.5	< 9.2	< 6.3	5.5	< 31.0	86.6	6.5	< 29.2
	Maximum	< 2.5	< 20.0	< 17.5	< 9.2	< 6.3	11.2	< 31.0	240.0	17.0	< 29.2
Vent 19	Average	< 2.5	< 20.0	< 17.5	< 9.2	< 6.3	4.7	< 31.0	< 2.5	< 2.6	< 29.2
	Maximum	< 2.5	< 20.0	< 17.5	< 9.2	< 6.3	4.7	< 31.0	< 2.5	< 2.6	< 29.2
Vent 22	Average	< 2.5	< 20.0	92.5	< 9.2	< 6.3	< 2.7	< 31.0	34.5	4.8	< 29.2
	Maximum	< 2.5	< 20.0	95.0	< 9.2	< 6.3	3.8	< 31.0	41.0	5.8	< 29.2
Vent 23	Average	< 2.5	< 20.0	230.0	< 9.2	< 6.3	< 2.7	< 31.0	250.0	7.1	< 29.2
	Maximum	< 2.5	< 20.0	230.0	< 9.2	< 6.3	< 2.7	< 31.0	250.0	7.1	< 29.2

< ### Indicates concentration less than the lower certified reporting level
μg/m³ Micrograms per cubic meter

CLC6H5 - Chlorobenzene
DBCP - Dibromochloropropane
DCPD - Dicyclopentadiene
DMDS - Dimethyldisulfide
ETC6H5 - Ethylbenzene
MEC6H5 - Toluene
MIBK - Methy isobutylketone
TCLEE - Tetrachloroethene
TRCLE - Trichloroethene
XYLENES - Total Xylenes

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included benzene and dicyclopentadiene. All analytes showed wide variations in concentrations. Individual analytical results for all waste pile vents and liquid storage vent samples are given in Appendix H. Short-term variances in emission rates and airflow turbulence at the locations where direct readings and VOC samples were obtained possibly contribute to the observed instrumental and analytical differences. Still, the use of a nonspeciating, direct-reading instrument remains the most practical method of selecting vents to sample when the prohibitive cost of laboratory analysis for sampling at all vents is considered.

4.9.4 Pond A and Tank Farm Monitoring Results

Results of real-time monitoring at the Pond A vents are presented in Table 4.9-4. The NH_3 and H_2S results were typically 0.0 ppm with the exception of H_2S readings ranging from 0.007 to 0.011 ppm at the four vents on January 4, 1993. OVM results were all 0.0 ppm with the exception of consistent readings of 0.4 ppm at all four vents on August 23, 1993. Pond A vent measurements performed using the OVA ranged from 0.0 to 40.0 ppm. Averaged OVA readings for all four vents indicate concentrations of 7.1, 0.6, 6.4, and 13.5 ppm for the north, east, south, and west vents, respectively.

Analytical results for Pond A vent samples are presented in Table 4.9-5. Compounds detected included 1,1,1-trichloroethane, 1,1-dichloroethane, benzene, methylene chloride, chloroform, dimethylsulfide, toluene, tetrachloroethene, total xylenes, and trichloroethene.

Results of real-time monitoring for the Basin F tank farm are presented in Table 4.9-6. Measurements made with the real-time instruments ranged widely for each parameter and among the three tanks. Averaged OVA readings indicate values of 10.1, 10.3, and 12.0 ppm for the north, east, and south tanks, respectively. On September 8, 1993, a measurement of 22.0 ppm at the south side tank vent was observed as the maximum OVA measurement. The highest OVM measurement, 12.0 ppm, was observed on September 8, 1993, also at the south tank vent. The highest NH_3 measurement, 28.0 ppm, was measured on July 2, 1993 at the north tank vent.

Table 4.9-4 Pond A Real-Time Monitoring Results

Date	Location	OVA (ppm)	OVM (ppm)	NH_3 (ppm)	H_2S (ppm)
1/04/93	Pond A Liner Vents - North Vent	0.0	0.0	0.0	0.010
	Pond A Liner Vents - East Vent	0.0	0.0	0.0	0.010
	Pond A Liner Vents - South Vent	0.8	0.0	0.0	0.007
	Pond A Liner Vents - West Vent	0.0	0.0	0.0	0.011
3/29/93	Pond A Liner Vents - North Vent	11.0	0.0	0.0	0.000
	Pond A Liner Vents - East Vent	0.0	0.0	0.0	0.000
	Pond A Liner Vents - South Vent	0.0	0.0	0.0	0.000
	Pond A Liner Vents - West Vent	40.0	0.0	0.0	0.000
7/15/93	Pond A Liner Vents - North Vent	7.2	0.0	0.0	0.000
	Pond A Liner Vents - East Vent	2.2	0.0	0.0	0.000
	Pond A Liner Vents - South Vent	12.0	0.0	0.0	0.000
	Pond A Liner Vents - West Vent	1.8	0.0	0.0	0.000
8/23/93	Pond A Liner Vents - North Vent	10.1	0.4	0.0	0.000
	Pond A Liner Vents - East Vent	0.0	0.4	0.0	0.000
	Pond A Liner Vents - South Vent	12.6	0.4	0.0	0.000
	Pond A Liner Vents - West Vent	12.0	0.4	0.0	0.000

OVA - Organic Vapor Analyzer
OVM - Organic Vapor Meter
NH_3 - Ammonia
H_2S - Hydrogen sulfide
ppm - Parts per million

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Table 4.9-5 Summary of FY93 Pond A Volatile Organic Compound Concentrations (μg/m³)

		111TCE	112TCE	11DCLE	12DCLE	12DCE	BCHPD	C6H6	CCL4	CH2CL2	CHCL3
Pond A	Average	44.8	< 7.1	2.6	< 2.4	< 2.4	< 2.4	3.5	< 3.5	37.8	3.4
	Maximum	113.0	< 7.1	6.9	< 2.4	< 2.4	< 2.4	9.4	< 3.5	102.0	6.9

		CLC6H5	DBCP	DCPD	DMDS	ETC6H5	MEC6H5	MIBK	TCLEE	TRCLE	XYLENES
Pond A	Average	< 2.5	< 20.0	< 17.5	66.5	< 6.3	9.6	< 31.0	141.0	82.1	< 29.2
	Maximum	< 2.5	< 20.0	< 17.5	160.0	9.6	26.5	< 31.0	333.0	196.0	36.9

< ### indicates concentration less than the lower certified reporting limit
μg/m³ Micrograms per cubic meter

111TCE	-	1,1,1-Trichloroethane	BCHPD	-	Bicycloheptadiene	CLC6H5	-	Chlorobenzene	MEC6H5	-	Toluene
112TCE	-	1,1,2-Trichloroethane	C6H6	-	Benzene	DBCP	-	Dibromochloropropane	MIBK	-	Methyl Isobutyl Ketone
11DCLE	-	1,1-Dichloroethane	CCL4	-	Carbon Tetrachloride	DCPD	-	Dicyclopentadiene	TCLEE	-	Tetrachloroethene
12DCLE	-	1,2-Dichloroethane	CH2CL2	-	Methylene Chloride	DMDS	-	Dimethyldisulfide	TRCLE	-	Trichloroethene
12DCE	-	trans-1,2-Dichloroethene	CHCL3	-	Chloroform	ETC6H5	-	Ethylbenzene	XYLENES	-	Total Xylenes

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Table 4.9-6 Basin F Tank Farm Monitoring Results

Date	Location	OVA (ppm)	OVM (ppm)	NH_3 (ppm)	H_2S (ppm)
1/04/93	Basin F Tank Farm - North Tank	9.6	0.0	0.0	0.100
	Basin F Tank Farm - East Tank	11.8	2.5	0.0	0.170
	Basin F Tank Farm - South Tank	6.0	0.0	0.0	0.130
3/23/93	Basin F Tank Farm - North Tank	0.6	0.0	Trace	0.018
	Basin F Tank Farm - East Tank	6.0	0.0	Trace	0.020
	Basin F Tank Farm - South Tank	11.0	0.5	2.0	0.016
7/2/93	Basin F Tank Farm - North Tank	12.2	7.6	28.0	0.000
	Basin F Tank Farm - East Tank	11.4	0.0	9.0	0.000
	Basin F Tank Farm - South Tank	9.1	0.0	12.0	0.000
9/8/93	Basin F Tank Farm - North Tank	18.0	1.4	5.0	0.30
	Basin F Tank Farm - East Tank	12.0	5.4	4.0	0.36
	Basin F Tank Farm - South Tank	22.0	12.0	19.0	0.55

OVA - Organic Vapor Analyzer
OVM - Organic Vapor Meter
NH_3 - Ammonia
H_2S - Hydrogen sulfide
ppm - Parts per million

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A reading of 0.55 ppm was measured as the highest H_2S concentration and was observed on September 8, 1993 at the south tank vent.

Results of the tank farm vent VOC sample analyses are presented in Table 4.9-7. Dimethyldisulfide was found to have the highest average and maximum 24 concentrations, 410.8 μg/m^3 and 990.0 μg/m^3, respectively was obtained at the east tank.

4.10 THE CAQMMP SQI SUPPORT PROGRAM

4.10.1 General

One of the major remedial activities at RMA during the FY93 period was the testing and operational implementation of the SQI facility to dispose of Basin F liquids held in three storage tanks and Pond A. The CAQMMP provided intensive air monitoring support to this activity. The air program consisted of the special use of four existing sampler locations from the ongoing CAQMMP network. These were located upwind and downwind from the SQI. Stations SQ1 and AQ3 were 1,000 feet north and 6,100 feet north-northeast of the SQI, respectively; and SQ2 and AQ6 were 500 feet and 12,000 feet south of the SQI, respectively (see Figure 4.10-1). As the wind flow over RMA is diurnally bimodal overall, these stations captured the prevailing winds and dispersion patterns that might influence pollutants emitted by the SQI facility.

Ambient air sampling was conducted every third day (twice the frequency of the routine CAQMMP sampling program), and every day during a special test program period (June 10 through June 12, 1993). The third-day sampling program began on April 16, 1993 and continued until July 12, 1993. There was a 9-day break in the sampling effort that occurred in early June. A total of 32 special SQI sampling events were conducted. In addition, the full CAQMMP network was used for sampling every sixth day. Finally, special high-event monitoring was conducted for the SQI assessment (see Section 4.6.4). Other features of the program included fast laboratory turnaround and prompt data reporting to PMRMA.

Table 4.9-7 Summary of FY93 Tank Farm Volatile Organic Compound Concentrations ($\mu g/m^3$)

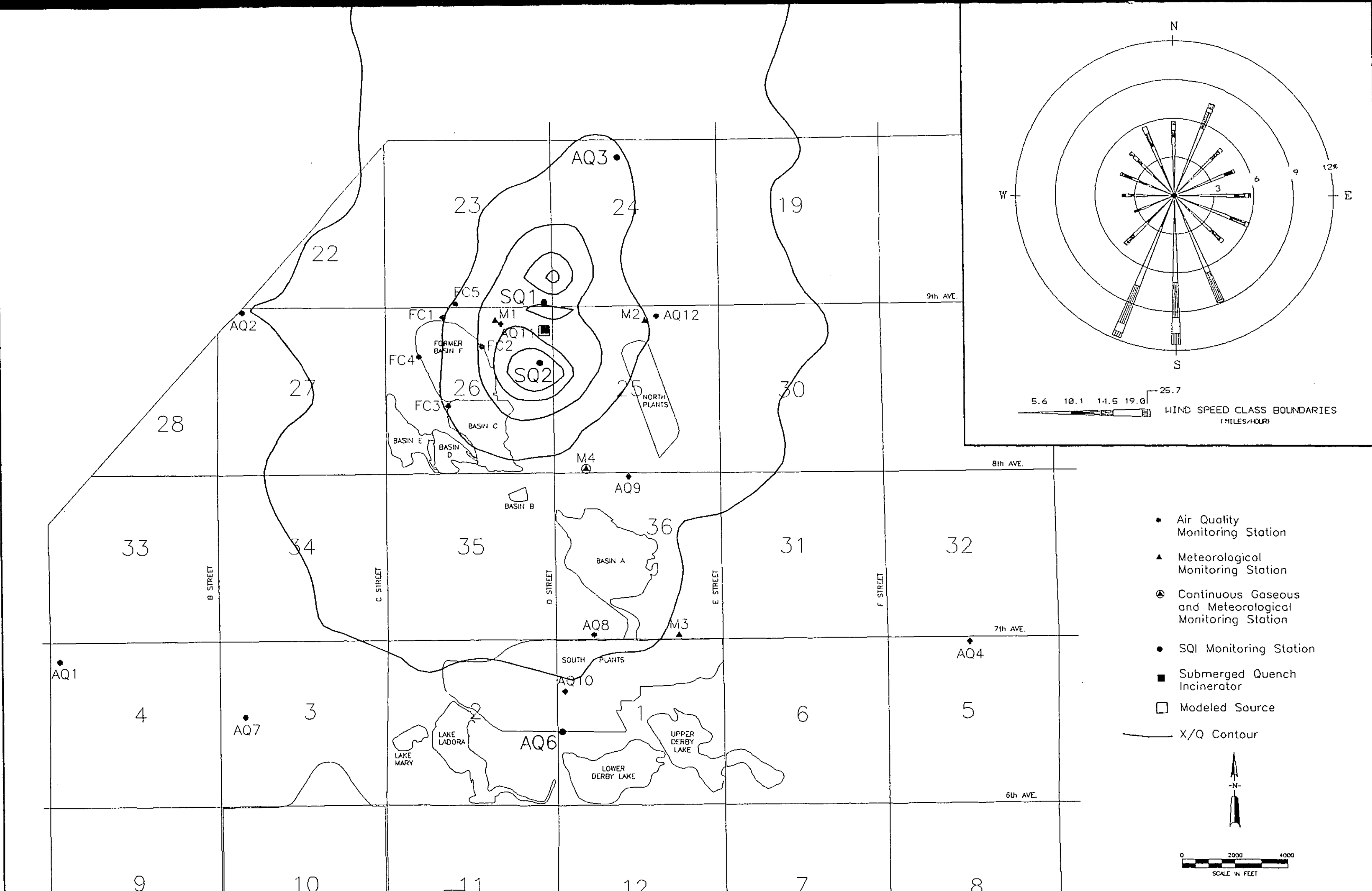
		111TCE	112TCE	11DCLE	12DCLE	12DCE	BCHPD	C6H6	CCL4	CH2CL2	CHCL3
East Tank	Average	< 4.5	< 7.1	< 2.4	< 2.4	< 2.4	< 2.4	3.9	< 3.5	25.7	6.8
	Maximum	8.9	< 7.1	< 2.4	< 2.4	< 2.4	4.9	6.7	< 3.5	88.1	19.0
North Tank	Average	< 4.5	< 7.1	< 2.4	< 2.4	< 2.4	< 2.4	< 3.1	< 3.5	< 15.0	< 2.4
	Maximum	7.1	< 7.1	< 2.4	< 2.4	< 2.4	< 2.4	< 3.1	< 3.5	< 15.0	3.2
South Tank	Average	6.5	< 7.1	< 2.4	< 2.4	< 2.4	2.7	4.7	< 3.5	49.1	23.1
	Maximum	19.1	< 7.1	< 2.4	< 2.4	< 2.4	7.2	8.0	< 3.5	102.0	46.0

		CLC6H5	DBCP	DCPD	DMDS	ETC6H5	MEC6H5	MIBK	TCLEE	TRCLE	XYLENES
East Tank	Average	6.3	< 20.0	67.3	410.8	< 6.3	38.5	< 31.0	9.6	< 2.6	< 29.2
	Maximum	19.0	< 20.0	190.0	990.0	< 6.3	92.0	90.0	25.0	< 2.6	< 29.2
North Tank	Average	< 2.5	< 20.0	< 17.0	91.8	< 6.3	4.2	< 31.0	< 2.5	< 2.6	< 29.2
	Maximum	3.6	< 20.0	< 17.0	240.0	< 6.3	9.9	< 31.0	< 2.5	< 2.6	< 29.2
South Tank	Average	9.2	< 20.0	113.7	216.0	< 6.3	65.5	< 31.0	11.1	< 2.6	< 29.2
	Maximum	17.0	< 20.0	230.0	340.0	< 6.3	110.0	44.0	19.0	< 2.6	< 29.2

111TCE	- 1,1,1-Trichloroethane	BCHPD	- Bicycloheptadiene	CLC6H5	- Chlorobenzene	MEC6H5	- Toluene
112TCE	- 1,1,2-Trichloroethane	C6H6	- Benzene	DBCP	- Dibromochloropropane	MIBK	- Methyl Isobutyl Ketone
11DCLE	- 1,1-Dichloroethane	CCL4	- Carbon Tetrachloride	DCPD	- Dicyclopentadiene	TCLEE	- Tetrachloroethene
12DCLE	- 1,2-Dichloroethane	CH2CL2	- Methylene Chloride	DMDS	- Dimethyldisulfide	TRCLE	- Trichloroethene
12DCE	- trans-1,2-Dichloroethene	CHCL3	- Chloroform	ETC6H5	- Ethylbenzene	XYLENES	- Total Xylenes

< ### Indicates concentration less than the lower certified reporting level
$\mu g/m^3$ Micrograms per cubic meter

RMA/1092 10/20/94 3:33 pm ap



Prepared for:
U.S. Army Program Manager
for Rocky Mountain Arsenal

Figure 4.10-1

X/Q Dispersion Pattern and
Wind Rose for SQI Monitoring Period

Rocky Mountain Arsenal
Prepared by: Ebasco Services Incorporated

Parameters monitored included the following:

- TSP
- PM-10
- RMA target metals compounds
- RMA target VOC compounds
- RMA target OCP compounds
- Gaseous criteria pollutants (SO_2, CO, NO_x, O_3)
- Meteorological parameters (wind speed and direction, temperature, atmospheric stability, barometric pressure, humidity, and precipitation)

Results of the sampling were compared with long-term data at individual monitoring stations, pre-SQI data compiled under the CMP/CAQMMP during FY91 and FY92, and previous peak concentrations at RMA during Basin F remediation activities. Dispersion modeling was also conducted to assist in the assessment of results.

Figure 4.10-1 shows the wind rose for the composite period of the SQI special monitoring program and the atmospheric dispersion pattern associated with meteorological conditions for the same period. Although all wind directions were evident during this period, the results substantiate the placement of the four-station special network close to potential peak impacts, as well as along the axis of the primary dispersion. All of the CAQMMP monitoring stations used in the assessment are also shown in this figure.

4.10.2 Results

Table 4.10-1 provides composite results of the SQI special monitoring program for SQ1, SQ2, AQ3, and AQ6. In order to identify significant concentration levels for each of the sampled parameters, and for each site, the table format is structured to contain the following information:

Table 4.10-1 Submerged Quench Incinerator Monitoring Results

Station: AQ3		Pre-SQI Startup Results				SQI 3rd Day Results 4/16/93 - 7/21/93	
	FY88-FY92	FY92		FY93			
Analyte	24-hour Max. (All RMA Sites)	AVG.	MAX.	AVG.	MAX.	Long Term Average	24-hour Maximum
1,1,1-Trichloroethane	72.54	1.105	2.460	1.716	4.854	1.344	2.530
1,1,2-Trichloroethane	4.00	< 0.170	< 0.170	< 0.170	< 0.170	< 0.170	< 0.170
1,1-Dichloroethane	0.27	< 0.056	< 0.056	< 0.056	< 0.056	< 0.056	< 0.056
1,2-Dichloroethane	3.80	< 0.056	0.166	< 0.056	0.301	< 0.056	0.120
trans-1,2-Dichloroethene	0.06	< 0.056	< 0.056	< 0.056	< 0.056	< 0.056	0.100
Bicycloheptadiene	39.46	< 0.056	< 0.056	< 0.056	0.148	< 0.056	< 0.056
Benzene	44.29	1.234	3.570	2.943	8.758	1.032	2.130
Carbon Tetrachloride	9.76	0.511	1.001	0.699	1.046	0.747	1.343
Methylene Chloride	433.69	1.824	4.709	1.396	5.310	34.545	395.
Chloroform	37.15	0.125	0.315	0.354	2.170	0.310	2.433
Chlorobenzene	2.53	< 0.060	< 0.060	< 0.060	0.068	< 0.060	< 0.060
Dibromochloropropane	17.04	< 0.463	< 0.463	< 0.463	< 0.463	< 0.463	< 0.463
Dicyclopentadiene	29.12	< 0.410	< 0.410	< 0.410	< 0.410	< 0.410	< 0.410
Dimethyldisulfide	36.72	< 0.220	< 0.220	< 0.220	< 0.220	< 0.220	< 0.220
Ethylbenzene	13.04	0.295	1.042	0.689	2.330	0.187	0.530
Toluene	158.04	2.106	4.779	5.345	22.330	1.857	5.300
Methyl Isobutyl Ketone	1.13	< 0.740	< 0.740	< 0.740	< 0.740	< 0.740	< 0.740
Tetrachloroethene	24.02	0.255	1.067	0.534	2.450	0.199	0.560
Trichloroethene	40.43	< 0.060	< 0.060	< 0.060	0.727	< 0.060	0.091
Total Xylenes	49.91	1.340	5.320	3.250	10.600	0.856	2.600

Note: All results in micrograms per cubic meter
FY92 averages and maximums do not include estimates for values above the upper Certified Reporting Limit

< ### Indicates concentration less than certified reporting limit
SQI Submerged Quench Incinerator

Table 4.10-1 Submerged Quench Incinerator Monitoring Results

Station: AQ6	Pre-SQI Startup Results					SQI 3rd Day Results 4/16/93 - 7/21/93	
	FY88-FY92 24-hour Max.	FY92		FY93			
Analyte	(All RMA Sites)	AVG.	MAX	AVG.	MAX.	Long Term Average	24-hour Maximum
1,1,1-Trichloroethane	72.54	N/A	N/A	2.301	6.161	1.407	2.820
1,1,2-Trichloroethane	4.00	N/A	N/A	< 0.170	< 0.170	< 0.170	< 0.170
1,1-Dichloroethane	0.27	N/A	N/A	< 0.056	< 0.056	< 0.056	< 0.056
1,2-Dichloroethane	3.80	N/A	N/A	< 0.056	0.070	< 0.056	0.130
trans-1,2-Dichloroethene	0.06	N/A	N/A	< 0.056	< 0.056	< 0.056	< 0.056
Bicycloheptadiene	39.46	N/A	N/A	< 0.056	< 0.056	< 0.056	< 0.056
Benzene	44.29	N/A	N/A	3.176	9.548	1.156	2.500
Carbon Tetrachloride	9.76	N/A	N/A	0.653	1.000	0.685	1.380
Methylene Chloride	433.69	N/A	N/A	1.912	11.510	36.405	441.
Chloroform	37.15	N/A	N/A	0.309	0.777	0.305	1.898
Chlorobenzene	2.53	N/A	N/A	< 0.060	< 0.060	< 0.060	< 0.060
Dibromochloropropane	17.04	N/A	N/A	< 0.463	< 0.463	< 0.463	< 0.463
Dicyclopentadiene	29.12	N/A	N/A	< 0.410	< 0.410	< 0.410	< 0.410
Dimethyldisulfide	36.72	N/A	N/A	< 0.220	< 0.220	< 0.220	< 0.220
Ethylbenzene	13.04	N/A	N/A	0.757	2.190	0.270	0.730
Toluene	158.04	N/A	N/A	5.975	26.066	2.507	6.100
Methyl Isobutyl Ketone	1.13	N/A	N/A	< 0.740	< 0.740	< 0.740	< 0.740
Tetrachloroethene	24.02	N/A	N/A	0.646	3.610	0.286	0.642
Trichloroethene	40.43	N/A	N/A	< 0.060	0.122	< 0.060	0.100
Total Xylenes	49.91	N/A	N/A	3.588	10.210	1.325	3.700

Note: All results in micrograms per cubic meter
N/A - No sampling results available for this time period

< ### Indicates concentration less than certified reporting limit
SQI Submerged Quench Incinerator

Table 4.10-1 Submerged Quench Incinerator Monitoring Results

Station: SQ1	Pre-SQI Startup Results					SQI 3rd Day Results 4/16/93 - 7/21/93	
	FY88-FY92	FY92		FY93			
Analyte	24-hour Max. (All RMA Sites)	AVG.	MAX.	AVG.	MAX.	Long Term Average	24-hour Maximum
1,1,1-Trichloroethane	72.54	1.230	3.469	2.310	13.130	1.250	2.830
1,1,2-Trichloroethane	4.00	< 0.170	< 0.170	< 0.170	< 0.170	< 0.170	< 0.170
1,1-Dichloroethane	0.27	< 0.056	< 0.056	< 0.056	< 0.056	< 0.056	< 0.056
1,2-Dichloroethane	3.80	< 0.056	0.081	< 0.056	0.058	< 0.056	0.078
trans-1,2-Dichloroethene	0.06	< 0.056	< 0.056	< 0.056	< 0.056	< 0.056	< 0.056
Bicycloheptadiene	39.46	< 0.056	< 0.056	< 0.056	< 0.056	< 0.056	< 0.056
Benzene	44.29	1.334	3.944	4.173	33.830	1.007	2.090
Carbon Tetrachloride	9.76	0.487	0.871	0.776	1.717	0.692	2.050
Methylene Chloride	433.69	1.511	4.770	1.889	13.574	34.843	305.
Chloroform	37.15	0.207	0.624	0.619	2.902	0.588	6.110
Chlorobenzene	2.53	< 0.060	< 0.060	< 0.060	< 0.060	< 0.060	< 0.060
Dibromochloropropane	17.04	< 0.463	< 0.463	< 0.463	< 0.463	< 0.463	< 0.463
Dicyclopentadiene	29.12	< 0.410	< 0.410	< 0.410	< 0.410	< 0.410	< 0.410
Dimethyldisulfide	36.72	< 0.220	< 0.220	< 0.220	< 0.220	< 0.220	< 0.220
Ethylbenzene	13.04	0.339	1.247	1.250	14.120	0.208	0.602
Toluene	158.04	2.279	5.090	8.561	87.560	1.905	5.200
Methyl Isobutyl Ketone	1.13	< 0.740	< 0.740	< 0.740	< 0.740	< 0.740	< 0.740
Tetrachloroethene	24.02	0.377	1.583	1.126	16.780	0.242	0.680
Trichloroethene	40.43	< 0.056	0.086	0.065	0.657	< 0.060	0.120
Total Xylenes	49.91	1.535	6.253	5.506	51.390	1.081	3.070

Note: All results in micrograms per cubic meter
FY 92 averages and maximums do not include estimates for values above the upper CRL

< ### Indicates concentration less than certified reporting limit
SQI Submerged Quench Incinerator

Table 4.10-1 Submerged Quench Incinerator Monitoring Results

Station: SQ2	Pre-SQI Startup Results					SQI 3rd Day Results 4/16/93 - 7/21/93	
	FY88-FY92	FY92		FY93			
Analyte	24-hour Max. (All RMA Sites)	AVG.	MAX.	AVG.	MAX.	Long Term Average	24-hour Maximum
1,1,1-Trichloroethane	72.54	1.291	3.815	2.163	5.652	1.381	2.760
1,1,2-Trichloroethane	4.00	< 0.170	< 0.170	< 0.170	< 0.170	< 0.170	< 0.170
1,1-Dichloroethane	0.27	< 0.056	< 0.056	< 0.056	< 0.056	< 0.056	< 0.056
1,2-Dichloroethane	3.80	< 0.056	0.785	< 0.056	< 0.056	< 0.056	0.094
trans-1,2-Dichloroethene	0.06	< 0.056	< 0.056	< 0.056	< 0.056	< 0.056	0.200
Bicycloheptadiene	39.46	< 0.056	< 0.056	< 0.056	< 0.056	< 0.056	< 0.056
Benzene	44.29	1.359	3.734	3.544	11.304	1.181	2.500
Carbon Tetrachloride	9.76	0.518	1.104	0.711	2.100	0.757	1.760
Methylene Chloride	433.69	2.087	6.364	1.228	3.540	27.620	255.
Chloroform	37.15	0.225	0.961	0.539	1.670	0.602	3.650
Chlorobenzene	2.53	< 0.060	< 0.060	< 0.060	< 0.060	< 0.060	< 0.060
Dibromochloropropane	17.04	< 0.463	< 0.463	< 0.463	< 0.463	< 0.463	< 0.463
Dicyclopentadiene	29.12	< 0.410	< 0.410	< 0.410	< 0.410	< 0.410	< 0.410
Dimethyldisulfide	36.72	< 0.220	< 0.220	< 0.0220	< 0.220	< 0.220	< 0.220
Ethylbenzene	13.04	0.448	2.156	0.858	4.230	0.261	1.040
Toluene	158.04	2.591	6.186	6.186	29.800	2.254	6.600
Methyl Isobutyl Ketone	1.13	< 0.740	< 0.740	< 0.740	< 0.740	< 0.740	< 0.740
Tetrachloroethene	24.02	0.412	2.070	0.738	3.370	0.268	0.590
Trichloroethene	40.43	< 0.060	0.050	< 0.060	0.180	< 0.060	0.092
Total Xylenes	49.91	1.957	10.814	3.995	19.810	1.182	3.200

Note: All results in micrograms per cubic meter
FY 92 averages and maximums do not include estimates for values above the upper CRL

< ### Indicates concentration less than certified reporting limit
SQI Submerged Quench Incinerator

Table 4.10-1 Submerged Quench Incinerator Monitoring Results

Station: AQ3		Pre-SQI Startup Results				SQI 3rd Day Results 4/16/93 - 7/21/93	
	FY88-FY92	FY92		FY93			
Analyte	24-hour Max. (All RMA Sites)	AVG.	MAX.	AVG.	MAX.	Long Term Average	24-hour Maximum
Aldrin	2.8290	0.0011	0.0011	< 0.0003	< 0.0003	< 0.0003	< 0.0003
Chlordane	0.0360	0.0008	0.0012	< 0.0003	< 0.0003	< 0.0003	0.0007
Dieldrin	2.2960	0.0006	0.0014	< 0.0003	< 0.0003	< 0.0003	0.0012
Endrin	1.0954	0.0018	0.0018	< 0.0003	< 0.0003	< 0.0003	< 0.0003
Isodrin	0.9450	0.0021	0.0021	< 0.0003	< 0.0003	< 0.0003	< 0.0003
PPDDE	0.0390	< 0.0003	< 0.0003	< 0.0003	< 0.0003	< 0.0003	< 0.0003
PPDDT	0.0585	< 0.0003	< 0.0003	< 0.0003	0.0005	< 0.0003	< 0.0003
Cadmium	0.0281	< 0.0025	< 0.0025	< 0.0025	0.0062	< 0.0025	< 0.0025
Chromium	0.2858	< 0.0123	0.0158	< 0.0123	< 0.0123	< 0.0123	< 0.0123
Copper	1.4980	0.0872	0.1950	0.0770	0.1290	0.0858	0.1400
Lead	0.0984	< 0.0245	0.0347	< 0.0245	0.0379	< 0.0245	< 0.0245
Zinc	3.3576	0.0240	0.0500	0.0289	0.0853	0.0196	0.3660
Arsenic	0.0136	< 0.0009	0.0013	< 0.0009	0.0016	< 0.0009	0.0011
Mercury	7.3000	< 0.2315	< 0.2315	< 0.2315	< 0.2315	< 0.2315	0.2940
TSP	902	37	83	30	68	31	69
PM-10	168	22	41	22	41	17	26

Note: All results in micrograms per cubic meter

< ### Indicates concentration less than certified reporting limit
SQI Submerged Quench Incinerator
TSP Total Suspended Particulates
PM-10 Particulate Matter less thatn 10 Micrometers

Table 4.10-1 Submerged Quench Incinerator Monitoring Results

Station: AQ6	Pre-SQI Startup Results					SQI 3rd Day Results 4/16/93 - 7/21/93	
	FY88-FY92	FY92		FY93			
Analyte	24-hour Max. (All RMA Sites)	AVG.	MAX.	AVG.	MAX.	Long Term Average	24-hour Maximum
Aldrin	2.8290	N/A	N/A	< 0.0003	< 0.0003	< 0.0003	0.0009
Chlordane	0.0360	N/A	N/A	< 0.0003	0.0018	0.0007	0.0031
Dieldrin	2.2960	N/A	N/A	0.0003	0.0019	0.0009	0.0041
Endrin	1.0954	N/A	N/A	< 0.0003	< 0.0003	< 0.0003	< 0.0003
Isodrin	0.9450	N/A	N/A	< 0.0003	< 0.0003	< 0.0003	< 0.0003
PPDDE	0.0390	N/A	N/A	< 0.0003	< 0.0003	< 0.0003	< 0.0003
PPDDT	0.0585	N/A	N/A	< 0.0003	< 0.0003	< 0.0003	< 0.0003
Cadmium	0.0281	N/A	N/A	< 0.0025	0.0073	< 0.0025	< 0.0025
Chromium	0.2858	N/A	N/A	< 0.0123	< 0.0123	< 0.0123	< 0.123
Copper	1.4980	N/A	N/A	0.0806	0.1710	0.0785	0.1550
Lead	0.0984	N/A	N/A	< 0.0245	0.0478	< 0.0245	< 0.0245
Zinc	3.3576	N/A	N/A	0.0305	0.1000	0.0189	0.0346
Arsenic	0.0136	N/A	N/A	< 0.0009	0.0016	0.0009	0.0139
Mercury	7.3000	N/A	N/A	< 0.2315	0.2790	< 0.2315	0.394
TSP	902	36	83	30	65	28	82
PM-10	168	N/A	N/A	19	39	15	27

Note: All results in micrograms per cubic meter
N/A - No sampling results available for this time period

< ### Indicates concentration less than certified reporting limit
SQI Submerged Quench Incinerator
TSP Total Suspended Particulates
PM-10 Particulate Matter less thatn 10 Micrometers

Station: SQ1	Pre-SQI Startup Results					SQI 3rd Day Results 4/16/93 - 7/21/93	
	FY88-FY92	FY92		FY93			
Analyte	24-hour Max. (All RMA Sites)	AVG.	MAX.	AVG.	MAX.	Long Term Average	24-hour Maximum
Aldrin	2.8290	0.0010	0.0021	< 0.0003	< 0.0003	< 0.0003	< 0.0003
Chlordane	0.0360	0.0016	0.0067	< 0.0003	< 0.0003	0.0003	0.0014
Dieldrin	2.2960	0.0015	0.0054	< 0.0003	0.0009	0.0009	0.0051
Endrin	1.0954	0.0005	0.0005	< 0.0003	< 0.0003	< 0.0003	0.0004
Isodrin	0.9450	< 0.0003	< 0.0003	< 0.0003	< 0.0003	< 0.0003	< 0.0003
PPDDE	0.0390	< 0.0003	< 0.0003	< 0.0003	< 0.0003	< 0.0003	< 0.0003
PPDDT	0.0585	< 0.0003	< 0.0003	< 0.0003	< 0.0003	< 0.0003	< 0.0003
Cadmium	0.0281	< 0.0025	0.0030	< 0.0025	0.0087	< 0.0025	< 0.0025
Chromium	0.2858	< 0.0123	0.0196	< 0.0123	< 0.0123	< 0.123	< 0.0123
Copper	1.4980	0.1228	0.3166	0.0517	0.0948	0.0105	0.1190
Lead	0.0984	< 0.0245	0.0346	< 0.0245	0.0497	< 0.0245	< 0.0245
Zinc	3.3576	0.0247	0.0650	0.0298	0.1000	0.0209	0.0873
Arsenic	0.0136	< 0.0009	0.0024	< 0.0009	0.0019	< 0.0009	0.0081
Mercury	7.3000	N/A	N/A	< 0.2315	< 0.2315	< 0.2315	0.2620
TSP	902	46	129	34	97	32	76
PM-10	168	26	56	25	50	18	30

Note: All results in micrograms per cubic meter
N/A - No sampling results available for this time period

< ### Indicates concentration less than certified reporting limit
SQI Submerged Quench Incinerator
TSP Total Suspended Particulates
PM-10 Particulate Matter less thatn 10 Micrometers

Station: SQ2 — Pre-SQI Startup Results — SQI 3rd Day Results 4/16/93 - 7/21/93

Analyte	FY88-FY92 24-hour Max. (All RMA Sites)	FY92 AVG.	FY92 MAX.	FY93 AVG.	FY93 MAX.	Long Term Average	24-hour Maximum
Aldrin	2.8290	0.0007	0.0009	< 0.0003	< 0.0003	< 0.0003	0.0006
Chlordane	0.0360	0.0021	0.0084	< 0.0003	< 0.0003	0.0005	0.0022
Dieldrin	2.2960	0.0014	0.0056	0.0003	0.0022	0.0013	0.0070
Endrin	1.0954	0.0005	0.0006	< 0.0003	< 0.0003	< 0.0003	< 0.0003
Isodrin	0.9450	< 0.0003	< 0.0003	< 0.0003	< 0.0003	< 0.0003	< 0.0003
PPDDE	0.0390	< 0.0003	< 0.0003	< 0.0003	< 0.0003	< 0.0003	< 0.0003
PPDDT	0.0585	< 0.0003	< 0.0003	< 0.0003	< 0.0003	< 0.0003	< 0.0003
Cadmium	0.0281	< 0.0025	0.0029	< 0.0025	0.0087	< 0.0025	0.0110
Chromium	0.2858	< 0.0123	0.0347	< 0.0123	< 0.0123	< 0.0123	< 0.0123
Copper	1.4980	0.0811	0.1442	0.0670	0.1120	0.0873	0.1320
Lead	0.0984	< 0.0245	0.0324	< 0.0245	0.0517	< 0.0245	0.0518
Zinc	3.3576	0.0263	0.0618	0.0294	0.1010	0.0197	0.0398
Arsenic	0.0136	< 0.0009	0.0010	< 0.0009	0.0014	< 0.0009	0.0047
Mercury	7.3000	N/A	N/A	< 0.2315	< 0.2315	< 0.2315	0.2220
TSP	902	44	120	27	80	32	79
PM-10	168	27	50	20	46	17	31

Note: All results in micrograms per cubic meter
N/A - No sampling results available for this time period

< ### Indicates concentration less than certified reporting limit
SQI Submerged Quench Incinerator
TSP Total Suspended Particulates
PM-10 Particulate Matter less thatn 10 Micrometers

- The maximum short-term (24-hour) concentration at RMA for each parameter or analyte measured during the CMP and CAQMMP (occurred mostly during the Basin F remediation period)

- The average long-term annual concentration at each station prior to startup (for FY92 and FY93)

- The maximum short-term concentration measured at the four monitoring stations sampling the SQI (SQ1, SQ2, AQ3, or AQ6) prior to SQI startup

- The average and maximum concentration at each station during every third-day SQI sampling program

This format allows for comparisons of SQI-sampled parameters and analytes with the highest short-term concentrations experienced at RMA during active remediation, as well as more recent baseline information prior to the SQI startup.

These data indicate that all TSP, PM-10, VOC, OCP, metals, arsenic, and mercury concentrations were at or below historical RMA levels with the exception of methylene chloride (discussed in Section 4.6.5.2 separately). With respect to PM-10 and TSP, there were no violations of short-term or longer-term standards. Maximum 24-hour concentrations of OCPs were smaller by a factor of at least 100 than the Basin F remediation levels. It appeared that dieldrin concentrations were slightly higher than recent pre-SQI startup levels; however, this could be a seasonal phenomenon. All metals levels were typical of RMA and urban background levels. There were several measurements of mercury during the SQI monitoring program; however, comparable measurements were sampled prior to SQI startup as reflected in Table 4.10-1.

VOCs were well below peak remediation concentrations (for those analytes identified as potential Basin F emissions) and were mostly typical of current RMA and regional levels. Carbon tetrachloride and chloroform levels were above recent FY93 concentrations, but well below peak RMA levels, and were typical of concentrations that have been experienced on occasion during the post-Basin F remediation monitoring programs.

There were no anomalous levels of gaseous criteria pollutants (SO_2, $N0_x$, CO, and O_3) measured at the CAQMMP monitoring site (approximately 1 mile south-southeast from the SQI) during the special SQI monitoring program.

4.11 THE SOIL VAPOR EXTRACTION SYSTEM SAMPLING PROGRAM

4.11.1 Overview

During FY93, PMRMA requested a special air monitoring task to be conducted in the area of the Motor Pool. This section describes the sampling procedures and results of the operational testing and air monitoring of the SVE system at the Motor Pool area from September 29 to October 1, 1993. This work was performed in accordance with the letter work plan submitted to PMRMA on September 10, 1993. The objective of this program was to furnish additional data to PMRMA for assessing the effectiveness of the remediation conducted under the Motor Pool Area IRA Soil Vapor Extraction Pilot Study in 1991.

A series of operational testing and three-phase air monitoring tasks were performed using the existing SVE system and soil gas monitoring wells at the Motor Pool area (Figure 4.11-1). Testing was conducted to verify the operability of the SVE system prior to the required 48-hour test run. During Phase I sampling, air samples were collected at the 12 soil gas monitoring wells and analyzed with an on-site Photovac 10S70 GC. A passivated canister sample (SUMMA) was then collected at the well site with the highest overall concentration of trichloroethene (TRCLE) and tetrachloroethene (TCLEE) and sent for analysis to the off-site laboratory. Phase II sampling was conducted during the 48-hour test run of the SVE. Canister samples were collected at the two vapor extraction well sites (VES-3 & VES-4) at hours 00, 16, 32, and 48 of the test period. Samples were also collected and analyzed with the on-site GC at hours 00 and 48. Phase II sampling replicated the sampling of the 12 soil gas monitoring wells that occurred during Phase I.

4.11.2 Operational Testing

The SVE system was inspected on September 9, 1993 prior to operational testing and deemed to be in adequate condition. The valves to the vapor extraction wells, VES-3 and VES-4, were

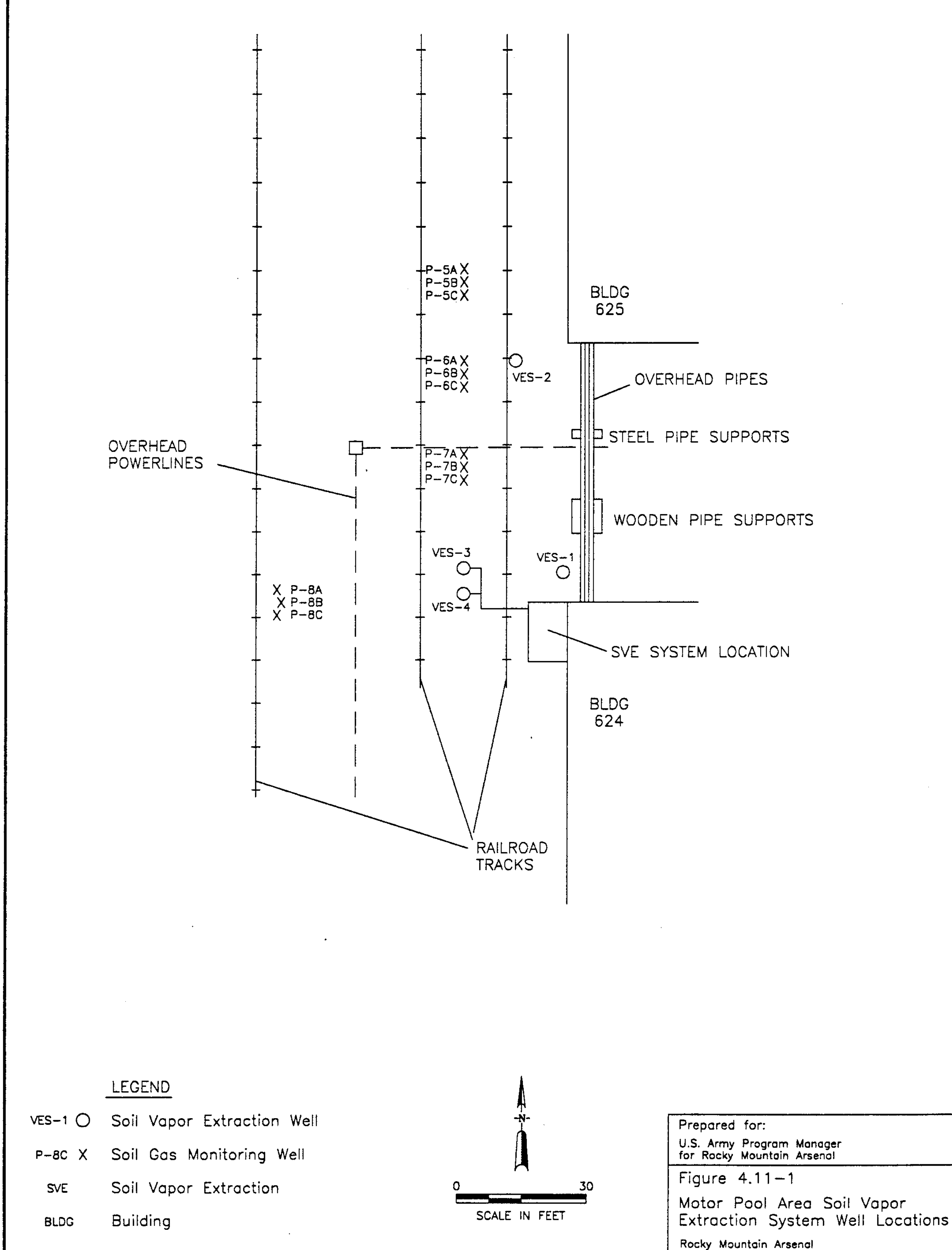


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Figure 4.11-1
Motor Pool Area Soil Vapor Extraction System Well Locations

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then closed to isolate subsurface vapors from the vacuum generated during testing. Valve V-1, located between the separator tank and the blower, was opened to provide an ambient air source for the system (Figure 4.11-2). The SVE system was turned on and allowed to operate for 10 minutes. Operational pressure/vacuum, temperature, and flow readings were taken. Based upon these readings (Table 4.11-1) and a visual inspection, the SVE was judged functional and capable of performing the full-scale 48-hour test run.

4.11.3 Phase I Sampling

Prior to startup of the 48-hour test run, soil gas samples were collected at the 12 soil gas monitoring wells (Figure 4.11-1). The Photovac GC was prepared and calibrated according to the procedures described in the work plan. The soil gas monitoring well samples were then collected in the following manner:

1) A short length of polyethylene tubing was connected to the monitoring well tubing using a compression fitting. A digital manometer was connected in line using a T-connector and a ball valve to control flow to the instrument. Then, an initial pressure/vacuum reading was recorded.

2) A hand-operated pump was attached to the 1/4-inch polyethylene tubing. Prior to collecting the sample, a predetermined volume of air was purged out of each well to ensure that the sample was not diluted by ambient air (1.5 liters for "A" wells, 2.0 liters for "B" wells, and 3.0 liters for "C" wells).

3) After allowing the system to return to ambient pressure, a 1.0-milliliter aliquot of soil gas was collected using a syringe inserted through a septum in the sample tube upstream of the vacuum pump.

4) The 1.0 milliliter soil gas aliquot sample was immediately injected into the GC for analysis for the target compounds: TRCLE and TCLEE.

5) The sampling apparatus was purged with hydrocarbon-free air between well tests.

Table 4.11-2 summarizes the results of this sampling. Based upon these results, a SUMMA canister sample was collected at well P-7A according to the procedures described in the work plan. This canister sample had TRCLE and TCLEE concentrations of 3.070 ppm and 0.007 ppm, respectively.

LEGEND

VES – SOIL VAPOR EXTRACTION WELL
PI – PRESSURE (VACUUM) INDICATOR
TI – TEMPERATURE INDICATOR
SP – SAMPLE PORT
V – VALVE
VRV – VACUUM RELIEF VALVE
GAC – GRANULAR ACTIVATED CARBON (VAPOR PHASE)

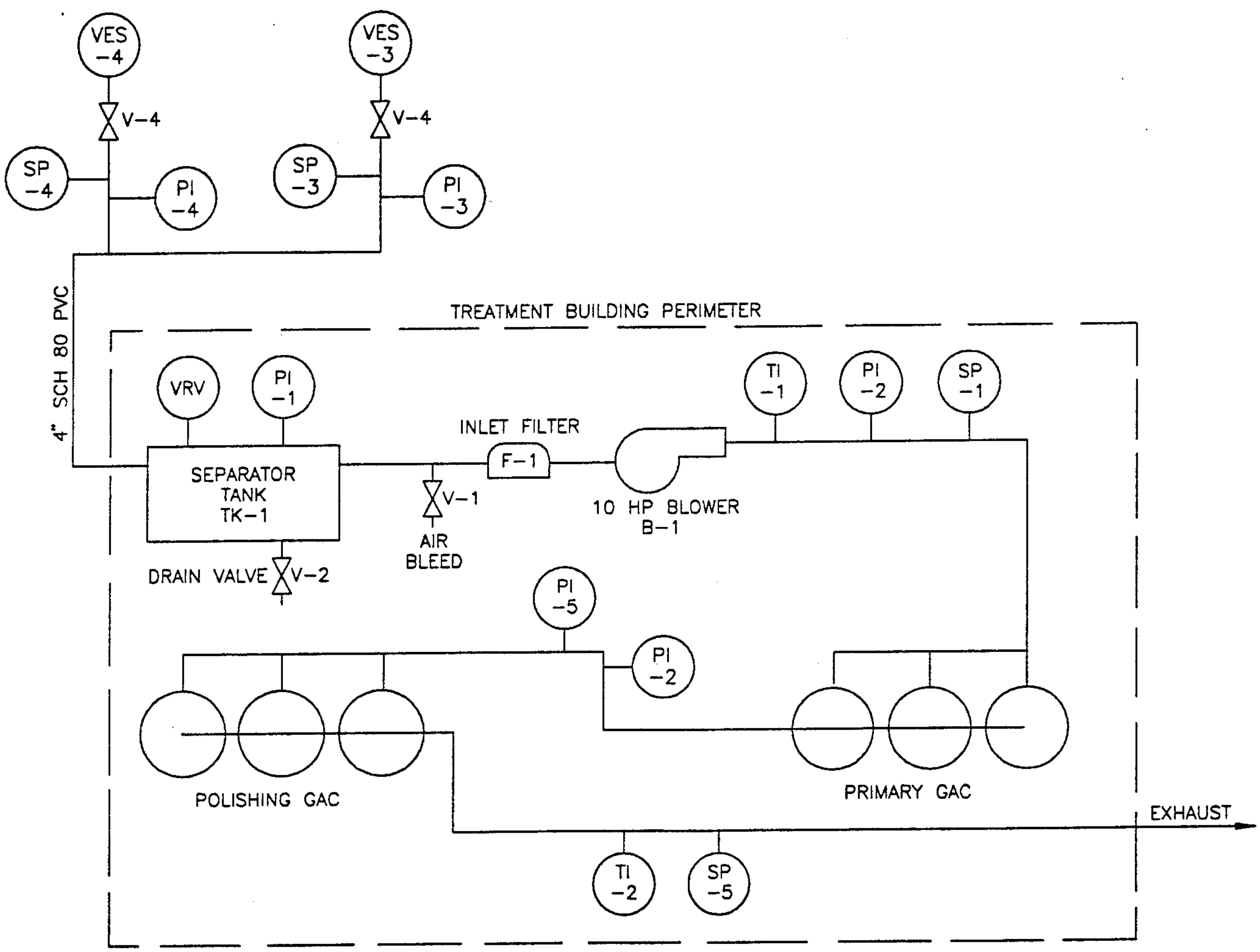

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Figure 4.11-2

Soil Vapor Extraction System Process Flow Diagram

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Table 4.11-1 Soil Vapor Extraction System Operational Testing Results

	Before Startup	After Startup
Pressure readings		
Separator Tank (PI-1)	1.5 inches H_2O	9.5 inches H_2O
Blower Exhaust (PI-2)	0.0 inches H_2O	14.0 inches H_2O
Post-Primary Granular Activated Carbon (PI-5)	0.0 inches H_2O	8.5 inches H_2O
Temperature readings		
Blower Exhaust (TI-1)	11.0 °C	41.0 °C
Post Granular Activated Carbon (TI-2)	14.0 °C	15.0 °C
Gas flow rate		
After Blower (SP-1)	0 feet per minute	6,000 feet per minute

°C - Degrees Celcius

Table 4.11-2 Phase I On-site GC Results for the Soil Gas Monitoring Wells

Soil Gas Monitoring Well	Trichloroethene (ppm)	Tetrachloroethene (ppm)
P5-A	1.400	0.020
P5-B	0.680	<0.015
P5-C	0.600	<0.015
P6-A	3.600	0.030
P6-B	0.790	0.050
P6-C	1.300	0.020
P7-A	5.400	0.020
P7-B	0.670	<0.015
P7-C	0.390	0.060
P8-A	0.300	<0.015
P8-B	0.070	<0.015
P8-C	0.360	<0.015

< ### Indicates concentration less than the instrument detection limit
ppm Parts per million

4.11.4 Phase II Sampling

During the 48-hour test run of the SVE, air samples were collected at the two soil vapor extraction well sites (VES-3 & VES-4) at hours 00, 16, 32, and 48. These samples were collected as follows:

1) The air flow from the extraction well was temporarily interrupted by closing the valve (V-3 & VES-4) at the extraction well (Figure 4.11-2).

2) A short length of polyethylene tubing was connected to the available sample port using a compression fitting.

3) The "T" sampling apparatus used in Phase I sampling was again utilized. The sample port was opened and a vacuum applied with the hand pump.

4) A syringe sample was collected and analyzed with the Photovac GC, as described previously. Also, a canister sample was collected by closing the ball valve to the pump and opening the canister's needle valve. At hours 16 and 32, only canister samples were collected.

5) Upon completion of sampling, flow was restored from the vapor extraction well.

Table 4.11-3 lists the results of the Phase II canister sampling. Table 4.11-4 details the concentrations detected by the on-site GC.

4.11.5 Phase III Sampling

After completion of the 48-hour test run, the system was allowed to equilibrate. Within several minutes, pressure/vacuum readings at the 12 soil gas monitoring wells had reached pre-testing levels. Soil gas samples were then collected at each well. These samples were collected in the same manner as in Phase I. Table 4.11-5 lists the results of this sampling. Based upon these results, a canister sample was collected at well P-7B. TRCLE and TCLEE concentrations were 2.390 and < 0.010 ppm, respectively, for this sample.

Table 4.11-3 Phase II SUMMA Canister Results for the Vapor Extraction Wells during the 48-Hour Test Run

Vapor Extraction Well	Time (hours into test run)	Trichloroethene (ppm)	Tetrachloroethene (ppm)*
VES-3	0.5	2.410	0.005
VES-3	16.0	4.150	0.005
VES-3	32.0	4.410	<0.010
VES-3	47.5	3.940	<0.010
VES-4	0.5	0.945	0.003
VES-4	16.0	1.800	<0.010
VES-4	32.0	0.752	<0.010
VES-4	47.5	0.703	<0.010

* Detection limit varies according to required sample dilution
< ### indicates concentration less than lower certified reporting limit
ppm Parts per million

Table 4.11-4 Phase II On-site GC Results for the Vapor Extraction Wells during the 48-Hour Test Run

Vapor Extraction Well	Time (hours into test run)	Trichloroethene (ppm)	Tetrachloroethene (ppm)
VES-3	0.5	4.300	<0.015
VES-3	47.5	1.400	<0.015
VES-4	0.5	2.000	<0.015
VES-4	47.5	0.380	<0.015

< ### Indicates concentration less than the lower certified reporting limit

ppm Parts per million

Table 4.11-5 Phase III On-site GC Results for the Soil Gas Monitoring Wells

Soil Gas Monitoring Well	Trichloroethene (ppm)	Tetrachloroethene (ppm)
P5-A	0.160	<0.015
P5-B	0.180	<0.015
P5-C	0.230	<0.015
P6-A	0.230	<0.015
P6-B	0.240	<0.015
P6-C	0.090	<0.015
P7-A	0.430	<0.015
P7-B	0.760	<0.015
P7-C	0.320	<0.015
P8-A	<0.015	<0.015
P8-B	0.020	<0.015
P8-C	0.310	<0.015

< ### Indicates concentrations less than the lower certified reporting limit

ppm Parts per million

4.11.6 Quality Assurance and Quality Control

Quality assurance and quality control procedures for the SVE sampling program consisted of collecting field duplicates and blank samples analyzed by the on-site GC and the off-site laboratory.

The on-site Photovac GC analyzed calibration standards, equipment blanks, instrument blanks, method blanks, and duplicate samples throughout the field program. Equipment blanks were taken with each sample set and involved the analysis of ambient air drawn through the decontaminated sampling apparatus when it was not connected to the well. Also, an aliquot of hydrocarbon-free air was drawn into the sample syringe and analyzed with the GC. Initial results indicated some minor carryover from the more concentrated samples; however, this was eliminated by flushing the sampling apparatus with hydrocarbon-free air between samples. Instrument blanks were performed daily and involved analysis with no injection. These illustrated no carryover contamination in the GC. The daily method blanks demonstrated the lack of background contamination of TRCLE and TCLEE in the ambient air. Table 4.11-6 highlights the satisfactory precision associated with the on-site GC sampling.

Table 4.11-7 lists the results of the duplicate canister sampling. These results demonstrate that the canister data were reliable. A canister sample of the hydrocarbon-free air used to purge the sampling apparatus between uses was also collected and analyzed. A small amount of TRCLE was detected (0.001 ppm) and no TCLEE was detected. Also, laboratory method blanks showed low levels of the TRCLE and methylene chloride. However, these quantities were insignificant when compared to the concentrations measured in the field samples (more than 100 times less). All data collected in the SVE air sampling program satisfied data quality objectives.

Non-target compound results for the canister samples are summarized in Table 4.11-8.

Table 4.11-6 On-site GC Duplicate Results

SITE	Trichloroethene (ppm)	Tetrachloroethene (ppm)
P-7A	5.400	0.020
P-7A Duplicate	3.200	<0.015
VES-3	4.300	<0.015
VES-3 Duplicate	3.900	<0.015
P-7B	0.760	<0.015
P-7B Duplicate	0.670	<0.015

< ### Indicates concentration less than the lower certified reporting limit

ppm Parts per million

Table 4.11-7 SUMMA Canister Duplicate Sample Results

SITE	Trichloroethene (ppm)	Tetrachloroethene (ppm)
VES-3	5.400	0.020
VES-3 Duplicate	3.200	< 0.015

< ### Indicates concentration less than the lower certified reporting limit

ppm Parts per million

Table 4.11-8 SUMMA Canister Results - Other Non-target Detections (ppbv)

P-7A (prior to 48 hour test run)

Chloroform = 1.49

Toluene = 1.24

Propylene = 1.65

1,1,2 - Trichlorethane = 1.99

Trans-1,2-Dichloroethene = 345

Benzene = 0.95

1,1,1-Trichloroethane = 0.84

VES-3 (hour 00 of test run)

Benzene = 0.93

Chloroform = 1.89

Ethylbenzene = 0.94

Toluene = 4.05

1,1,2-Trichloroethane = 3.25

m,p-Xylene = 0.78

Carbon Tetrachloride = 1.74

1,1-Dichloroethylene = 1.59

m,p-Xylene = 0.78

1,1,1-Trichloroethane = 3.01

Trans-1,2-Dichloroethene = 166

VES-4 (hour 00 of test run)

Benzene = 0.69

Chloroform = 8.52

Toluene = 26.6

1,1,2-Trichloroethane = 1.62

Carbon Tetrachloride = 2.17

1,1-Dichloroethylene = 16.1

1,1,1-Trichloroethane = 33.9

Trans-1,2-Dichloroethene = 33.5

VES-3 (hour 16 of test run)

Chloroform = 1.27

1,1,1-Trichloroethane = 1.79

Trans-1,2-Dichloroethene = 157

Toluene = 0.73

1,1,2-Trichloroethane = 5.15

Benzene = 0.54

VES-4 (hour 16 of test run)

1,4-Dichlorobenzene = 24.1

Ethylbenzene = 15.5

Methylene Chloride = 588

1,1,1-Trichloroethane = 26.1

Chlorodifluoromethane = 2080

1,1-Dichloroethylene = 11.3

m,p-Xylene = 54.9

Toluene = 414

1,2,4-Trimethylbenzene = 68.8

ppbv - Parts per billion volume

Table 4.11-8 SUMMA Canister Results - Other Non-target Detections (ppbv)

VES-3 (hour 32 of test run)

1,4-Dichlorobenzene = 27.2	Ethylbenzene = 20.6
m,p-Xylene = 64.8	Methylene Chloride = 869
o-Xylene = 30.7	Styrene = 36.7
Toluene = 493	1,2,4-Trimethylbenzene =75.9
1,3,5-Trimethylbenzene = 40.7	Chlorodifluoromethane = 3580
Hexane = 14.3	Trans-1,2-Dichloroethene = 23.5

VES-4 (hour 32 of test run)

1,4-Dichlorobenzene = 29.2	Ethylbenzene = 21.6
m,p-Xylene = 69.5	Methylene Chloride = 616
o-Xylene = 33.3	Styrene = 39.3
Toluene = 473	1,1,1-Trichloroethane = 20.7
1,2,4-Trimethylbenzene = 78.6	1,3,5-Trimethylbenzene = 21.4
Chlorodifluoromethane = 743	

VES-3 (hour 48 of test run)

1,4-Dichlorobenzene = 31.7	Ethylbenzene = 21.4
m,p-Xylene = 70.3	Methylene Chloride = 994
o-Xylene = 33.0	Styrene = 39.6
Toluene = 508	Trichlorofluoromethane = 12.0
1,2,4-Trimethylbenzene = 75.7	1,3,5-Trimethylbenzene = 20.4
Chlorodifluoromethane = 834	Pentane = 10.6
Hexane = 11.0	Trans-1,2-Dichloroethene = 20.4

ppbv - Parts per billion volume

VES-4 (hour 48 of test run)

1,4-Dichlorobenzene = 25.2	Ethylbenzene = 19.8
m,p-Xylene = 65.9	Methylene Chloride = 755
o-Xylene = 30.4	Styrene = 36.3
Toluene = 492	1,1,1-Trichloroethane = 21.3
1,2,4-Trimethylbenzene = 77.2	1,3,5-Trimethylbenzene = 21.0
Chlorodifluoromethane = 554	

P7-B (after 48 hour test run)

1,4-Dichlorobenzene = 27.3	Ethylbenzene = 23.8
m,p-Xylene = 78.8	Methylene Chloride = 649
o-Xylene = 37.3	Styrene = 42.9
Toluene = 571	1,1,1-Trichloroethane = 10.9
1,2,4-Trimethylbenzene = 80.8	1,3,5-Trimethylbenzene = 45.7
Chlorodifluoromethane = 801	Trans-1,2-Dichloroethene = 14.4

ppbv - Parts per billion volume

5.0 CONTINUOUS AIR MONITORING PROGRAM

5.1 PROGRAM OVERVIEW

The Continuous Air Monitoring Program is described in Section 3.4. Measurements of criteria gaseous pollutants were taken continuously and recorded automatically on a data acquisition system. Summary tables of hourly averages and graphs showing daily average and maxima of the sampling data for carbon monoxide (CO), ozone (O_3), sulfur dioxide (SO_2), nitric oxide (NO), nitrogen dioxide (NO_2), and nitrogen oxides (NO_x) are presented in Appendices I and J for FY93 (October 1, 1992 through September 30, 1993) and are summarized in this section.

5.1.1 Objectives

The principal objective of the gaseous monitoring program is to identify background concentrations of pollutants. These background levels play a role in possible future remediation activities because they provide insight into the atmospheric characteristics in and around the RMA site. This data assessment provides a general overview of the gaseous concentrations and highlights any anomalous values, while helping to identify meteorological and dispersion conditions that may affect general air quality at RMA. For instance, diurnal drainage winds from the south, which frequently occur at night, and upslope winds from the north during the day affect all six gas concentrations to some extent, as well as suspended particulate matter and VOCs within the Denver airshed. Diurnal drainage winds are described in more detail in Section 2.2. In addition, daytime photochemical activity primarily influences O_3 and NO_2.

A second objective of the Continuous Air Monitoring Program is to compare the criteria pollutant concentrations at RMA with those detected at nearby regional continuous air monitoring sites. These adjacent air monitoring sites are administrated by the CDH Air Pollution Control Division. Locations of the CDH continuous air monitoring sampling sites are illustrated in Figure 5.1-1 and described in Table 5.1-1. Although there are several CDH monitoring sites located in and around the Denver metropolitan area, this report primarily compares the monitoring site at RMA to the two adjacent CDH monitoring sites (the CAMP station located at 2105 Broadway in downtown Denver, and the Welby station, located at 78th and Steele streets in Commerce City). These sites

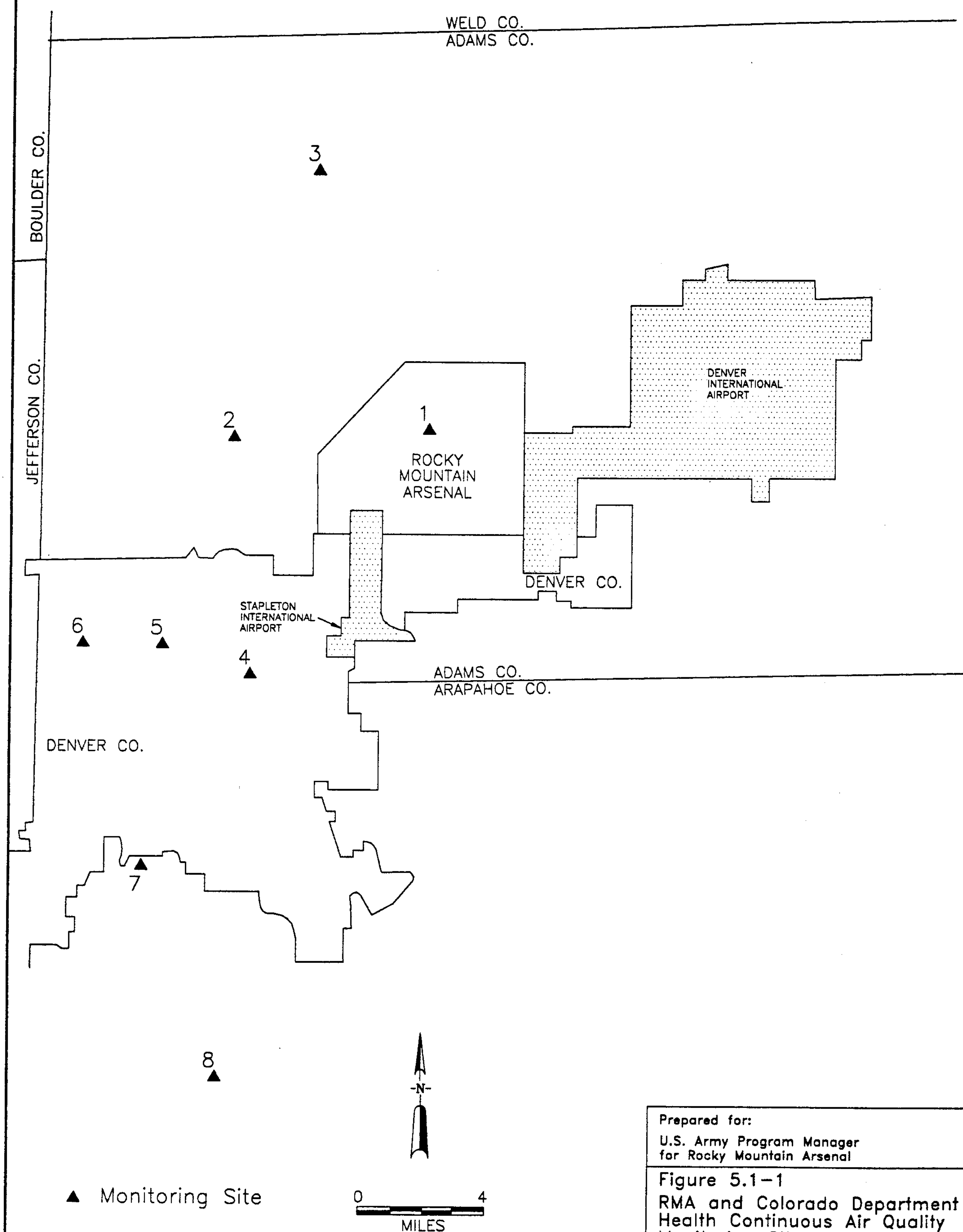

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Figure 5.1-1
RMA and Colorado Department of Health Continuous Air Quality Monitoring Sites

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Table 5.1-1 Continuous Air Quality Monitoring Sites in the Vicinity of Rocky Mountain Arsenal
Page 1 of 1

Map ID	Site Name	Site Address	CO	O_3	SO_2	NO	NO_2	NO_x	PM-10
			Reported Parameters						
1	RMA	8th Avenue at D Street	X	X	X	X	X	X	X+
2	Welby	78th and Steele	X	X	X	X	X		X
3	Brighton	140th and Quebec St		X					
4	Albion	14th at Albion	X						
5	CAMP	2105 Broadway	X	X	X	X	X		X
6	Carriage	23rd and Julian	X	X					
7	Englewood	Cinderella City	X	X		X	X		
8	Highland	8100 South University	X	X					

CO Carbon monoxide
O_3 Ozone
SO2 Sulfur dioxide
NO Nitric oxide
NO_2 Nitrogen oxide
NO_x Nitrogen oxides
PM-10 Particulate matter less than 10 micrometers
\+ 12 individual PM-10 sampling stations are installed at various locations across RMA

were chosen because they generally represent the Denver metropolitan area (CDH 1991) and because they are relatively close to RMA and are used for comparative representativeness to RMA.

The CAQMMP serves to establish background levels of ambient air quality for future assessments. Measured concentrations are compared with various meteorological data such as wind direction and atmospheric stability to identify migration patterns of gaseous pollutants from metropolitan Denver onto RMA. In addition, background levels are used to predict impacts of future remedial activity on the environment. The results shown in this section represent a complete year of data collection and provide an assessment of diurnal and annual cycles for each gas.

5.1.2 Data Recovery

Data recovery statistics for each of the monitored pollutants for FY93 are given in Table 5.1-2. Recoveries are based on the number of valid hourly measurements as compared to the total number of hours in the year. An observation was considered invalid or missing if there were less than 45 minutes of valid data recorded for the hour.

5.2 ANALYSIS OVERVIEW

A variety of tables and graphs were used to summarize continuous air quality data. Mean values, which refer to daily averages, and 1-hour maximum values, which refer to the highest 1-hour average values recorded each day, are provided. RMA data were compared to NAAQS and data from CDH stations. The analyses for carbon monoxide, ozone, and sulfur dioxide are presented individually in the following subsections. For nitrogen oxides, nitric oxide, and nitrogen dioxide, only total nitrogen oxides will be discussed because of the similarities in the chemical composition and concentration characteristics. Case studies were presented to examine the possible sources of some of the higher concentrations observed at RMA.

Table 5.1-2 Summary of Rocky Mountain Arsenal Continuous Monitoring Data Recovery for FY93

Parameter	Annual Recovery %
Ozone	99.0
Carbon Monoxide	99.1
Sulfur Dioxide	98.6
Nitric Oxide	96.6
Nitrogen Dioxide	96.6
Nitrogen Oxides	96.6

% Percent

5.3 CARBON MONOXIDE

Average carbon monoxide concentrations are depicted on monthly graphs in Appendix J. During the sample collection period for FY93, there were a number of occasions when the daily maximum concentration was several times greater than the daily average. There were also several occasions during this monitoring period when the daily maximum and the daily mean concentration were nearly the same value; such instances usually occurred when persistent winds were blowing from either a northerly or a southeasterly direction. These flows allowed industrial pollutant matter from metropolitan Denver to migrate away from RMA and not be detected.

Figure 5.3-1 presents the monthly mean CO values for FY93. The gradual increase in the monthly mean concentrations during the fall and winter seasons (evident in this figure) was primarily due to shallow and intense night surface inversions and very light winds. The high concentrations began to decrease when spring brought warmer temperatures and frequently unstable atmospheric conditions.

Monthly summaries of the 1-hour and 8-hour averages are shown in Tables 5.3-1 and 5.3-2, respectively. The National and Colorado Ambient Air Quality Standards for the 1-hour and 8-hour averages, 35 ppm and 9 ppm, respectively, were never exceeded during the FY93 sample collection period at RMA. The maximum observed 1-hour concentration was 7.7 ppm on January 14, 1993, between the hours of 2300 and 2400 MST. The maximum 8-hour concentration was 4.3 ppm on January 14-15, 1993, between the hours of 2000 and 0300 MST. These maximum RMA concentrations represent 22.0 and 47.8 percent of the 1- and 8-hour standards, respectively. Figure 5.3-2 presents the diurnal cycle for CO for FY93.

As indicated in the Assessment Reports for previous fiscal years, there are no major stationary sources of carbon monoxide in the RMA area. The high CO levels represent an influx of CO from vehicles during the Denver metropolitan morning rush-hour (0600 to 1000 MST). There is also an increase in CO concentrations during the evening hours between 1700 and 2200 MST. This evening increase may be the result of several factors, including the onset of the evening

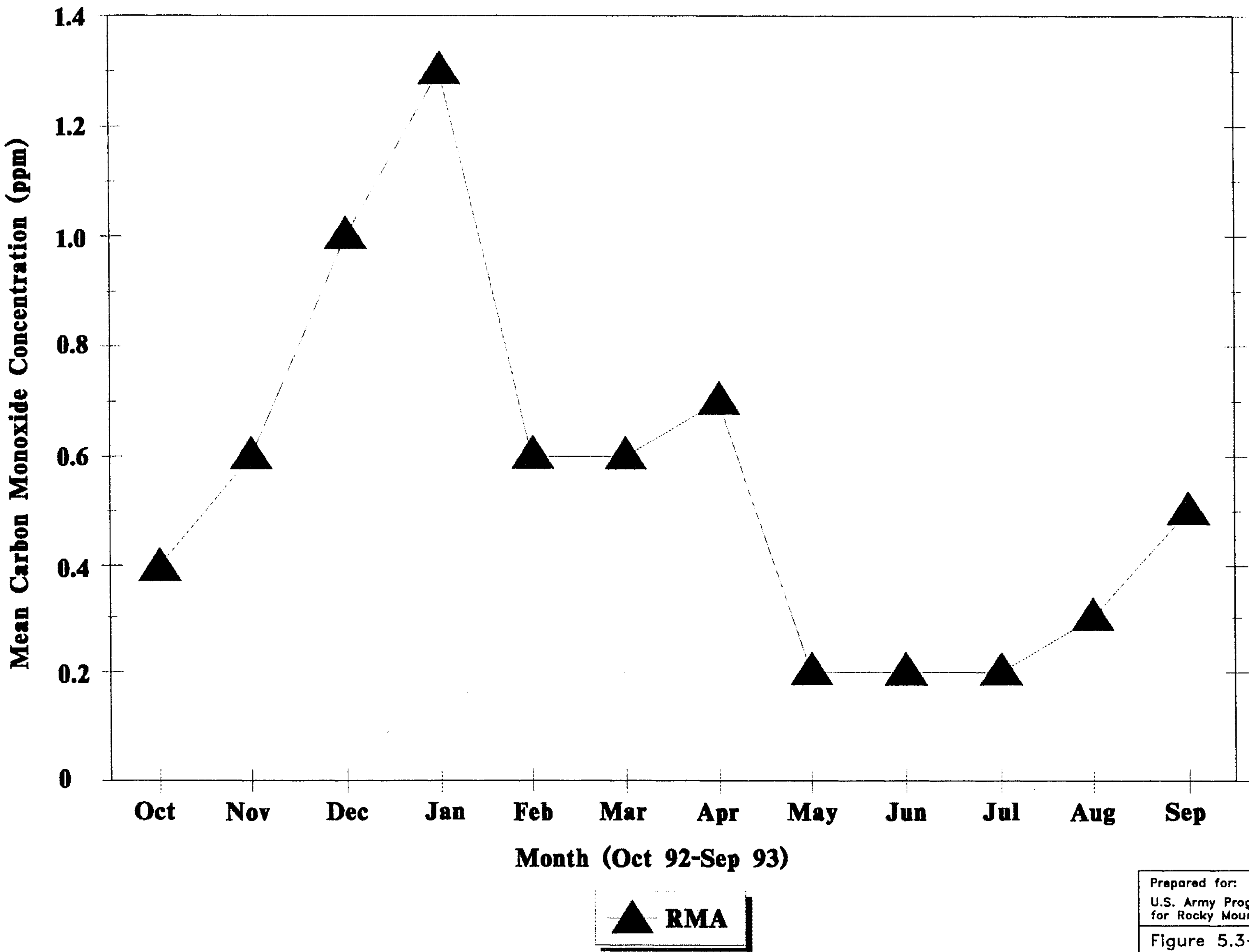

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Figure 5.3-1
RMA FY93 Monthly Mean
Carbon Monoxide Concentration

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Table 5.3-1 Summary of Carbon Monoxide 1-Hour Average Values in ppm[1]: October 1, 1992 (0100 MST) through September 30, 1993 (2400 MST)

	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
Mean	0.4	0.6	1.0	1.3	0.6	0.6	0.7	0.2	0.2	0.2	0.3	0.5
Maximum	3.3	3.8	6.7	7.7	4.7	2.7	2.3	2.1	2.1	1.4	1.3	2.2
2nd Highest Maximum	2.9	3.5	6.5	6.2	4.4	2.5	2.1	1.8	1.5	1.2	1.3	2.0
Minimum	0.1	0.1	0.1	0.5	0.1	0.2	0.1	0.1	0.1	0.1	0.1	0.1
Mean for Entire Period	0.54											

1 Federal and Colorado Ambient Air Quality Standard for maximum 1-hour average values is 35 ppm, not to be exceeded more than once a year.
MST Mountain Standard Time
ppm Parts per million

Table 5.3-2 Summary of Carbon Monoxide 8-Hour Average Values in ppm[1]: October 1, 1992 (0100 MST) through September 30, 1993 (2400 MST)

	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
Maximum	2.0	2.0	4.1	4.3	3.0	1.6	1.4	1.3	0.8	0.8	0.9	1.2
2nd Highest Maximum	2.0	2.0	4.0	4.3	3.0	1.6	1.4	1.3	0.8	0.7	0.8	1.2

1 Federal and Colorado Ambient Air Quality Standard for maximum 8-hour average values is 9 ppm, not to be exceeded more than once a year.
MST Mountain Standard Time
ppm parts per million

RMA/0863 10/06/94 1:06 pm bpw

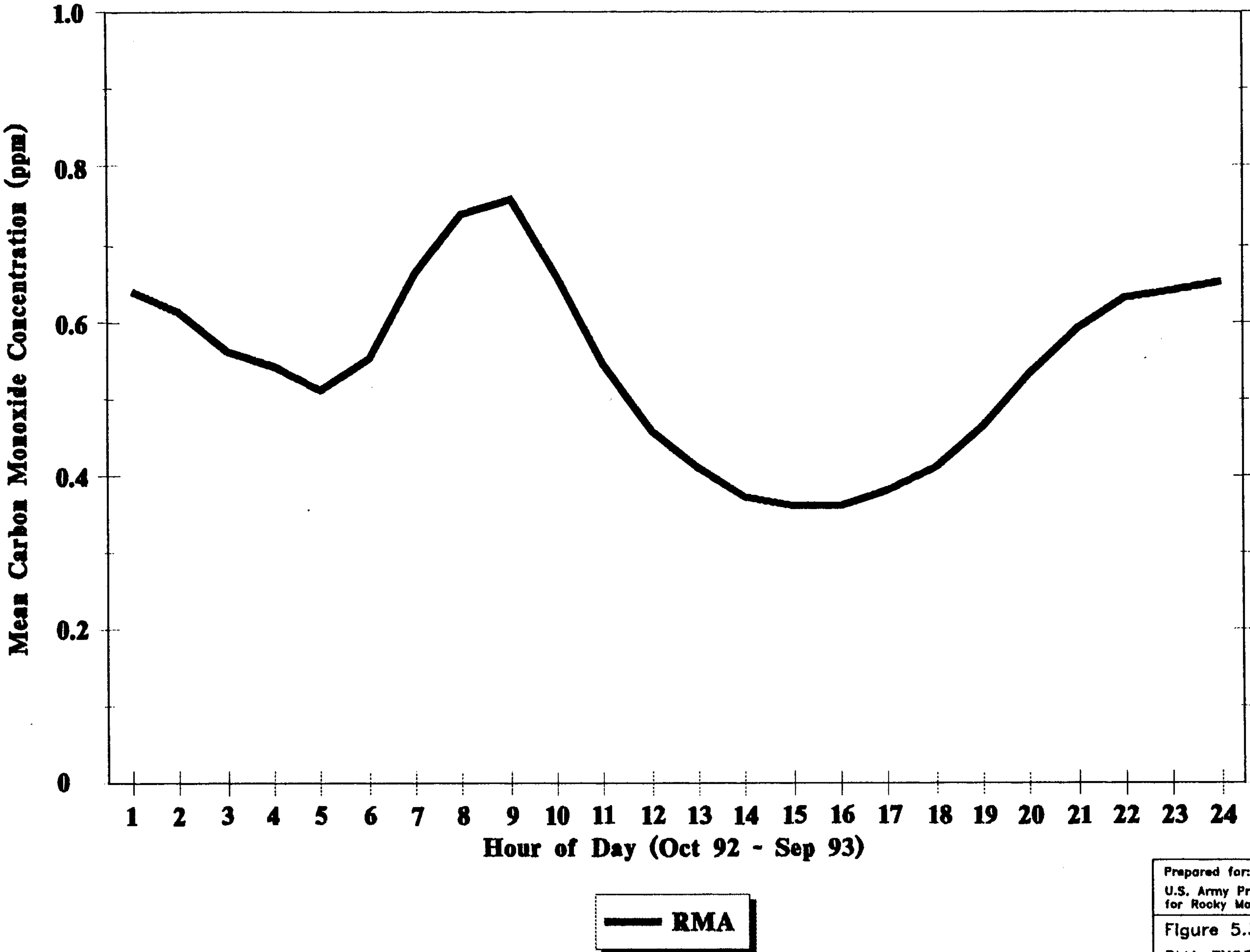

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Figure 5.3-2

RMA FY93 Diurnal Cycle for Carbon Monoxide Concentration

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inversion, a shift in the wind direction, evening heating of homes (especially those with wood stoves), and the evening rush hour.

Figures 5.3-3 and 5.3-4 compare the highest 1-hour and 8-hour carbon monoxide concentrations recorded at RMA to the two CDH sites, Welby and CAMP, for FY93. These two graphs show that concentrations recorded at RMA were lower than both CDH locations and significantly lower than the CAMP site for the fall and winter months.

5.4 OZONE

Table 5.4-1 presents a summary of monthly mean and maximum ozone concentrations at the RMA site for FY93. Figure 5.4-1 displays the monthly mean ozone values for FY93. This graph also illustrates a very evident annual cycle for ozone. During the late spring and through the summer ozone increased, with peak concentrations observed during June and July. The figure also shows minimum concentrations for ozone observed during the winter months.

A very distinct diurnal pattern for ozone is illustrated in Figure 5.4-2. Peak ozone concentrations occurred between the hours of 1300 and 1600 MST, when solar radiation played a major role in the formation of ozone. Ozone concentrations decreased after the peak hours and stabilized at lower levels between 2400 and 0500 MST. Between the hours of 0500 and 0700 MST, ozone concentrations were further reduced. This reduction may be due to the increase in NO, NO_2, and NO_x concentrations associated with the beginning of the Denver metropolitan area rush-hour; or the consumption of ozone in the conversion of NO to NO_2.

The highest ozone concentration, 0.099 ppm, was recorded on August 20, 1993, between the hours of 1400 and 1500 MST. This concentration represents 83 percent of the primary 1-hour National and Colorado Ambient Air Quality Standard of 0.120 ppm for ozone.

Figure 5.4-3 compares the highest 1-hour ozone concentrations recorded at RMA to the two CDH sites for the monitoring period. Concentrations at RMA were comparable but slightly higher than

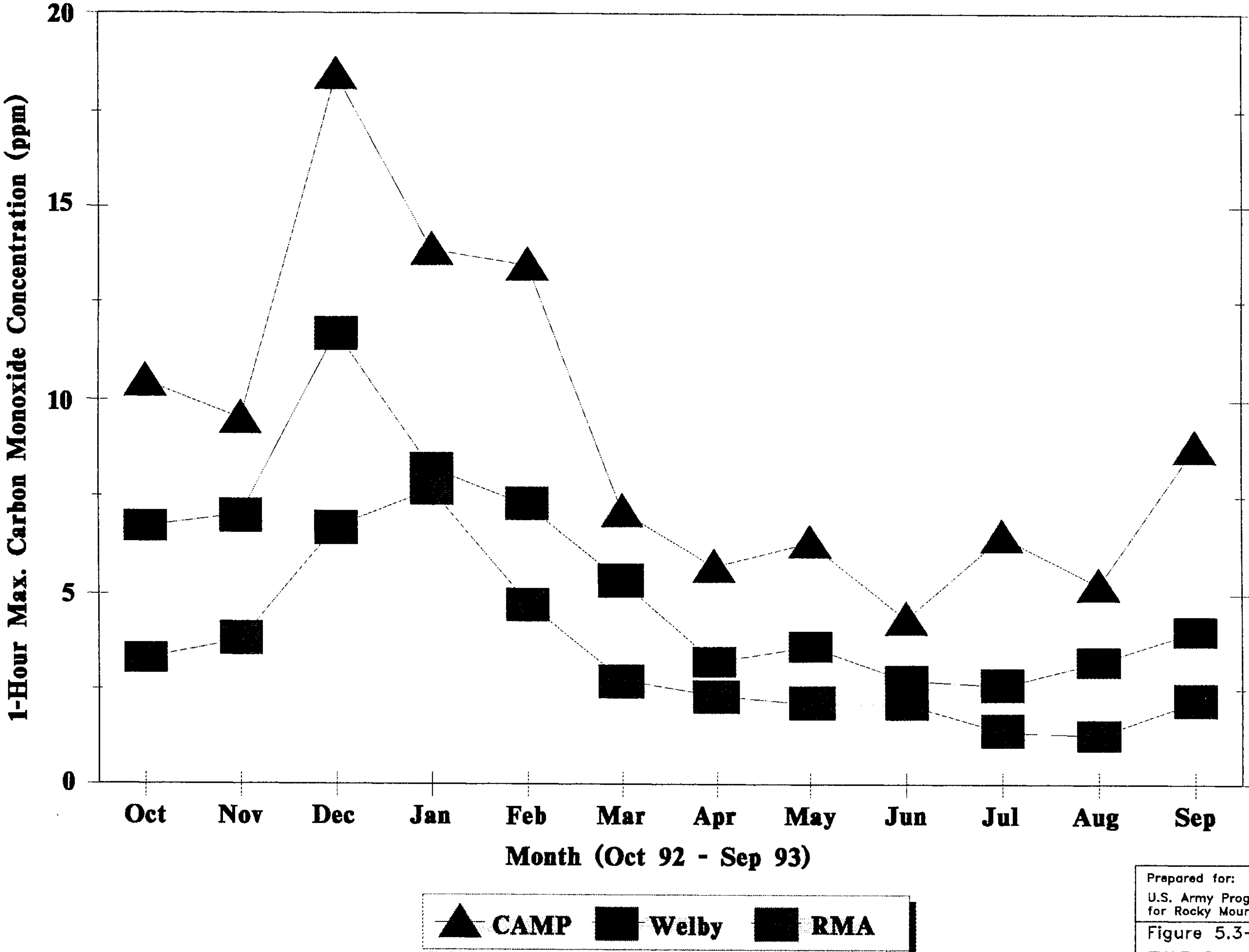

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Figure 5.3-3

FY93 Comparison of 1-Hour Maximum Carbon Monoxide Concentration for RMA and CDH Sites

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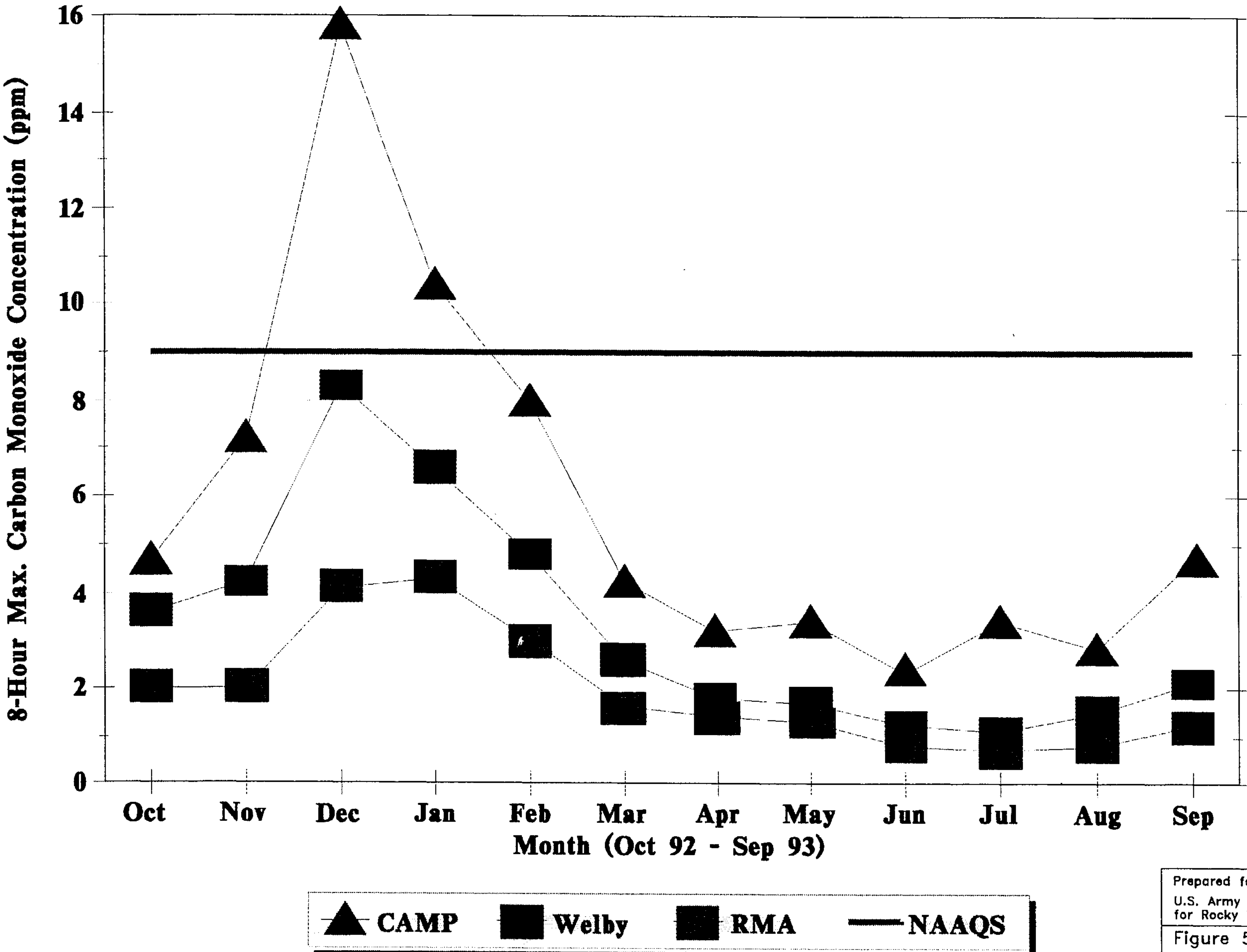

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Figure 5.3-4

FY93 Comparison of 8-Hour Maximum Carbon Monoxide Concentration for RMA and CDH Sites

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Table 5.4-1 Summary of Ozone 1-Hour Average Values in ppm[1]: October 1, 1992 (0100 MST) through September 30, 1993 (2400 MST)

	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
Mean	0.021	0.015	0.017	0.016	0.026	0.030	0.036	0.036	0.041	0.040	0.033	0.028
Maximum	0.073	0.063	0.044	0.045	0.062	0.063	0.075	0.081	0.088	0.085	0.099	0.067
2nd Highest Maximum	0.071	0.053	0.041	0.044	0.060	0.063	0.068	0.079	0.080	0.082	0.096	0.066
Minimum	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Mean for Entire Period	0.028											

1 Federal and Colorado Ambient Air Quality Standard for maximum 1-hour average values is 0.120 ppm.
MST Mountain Standard Time
ppm parts per million

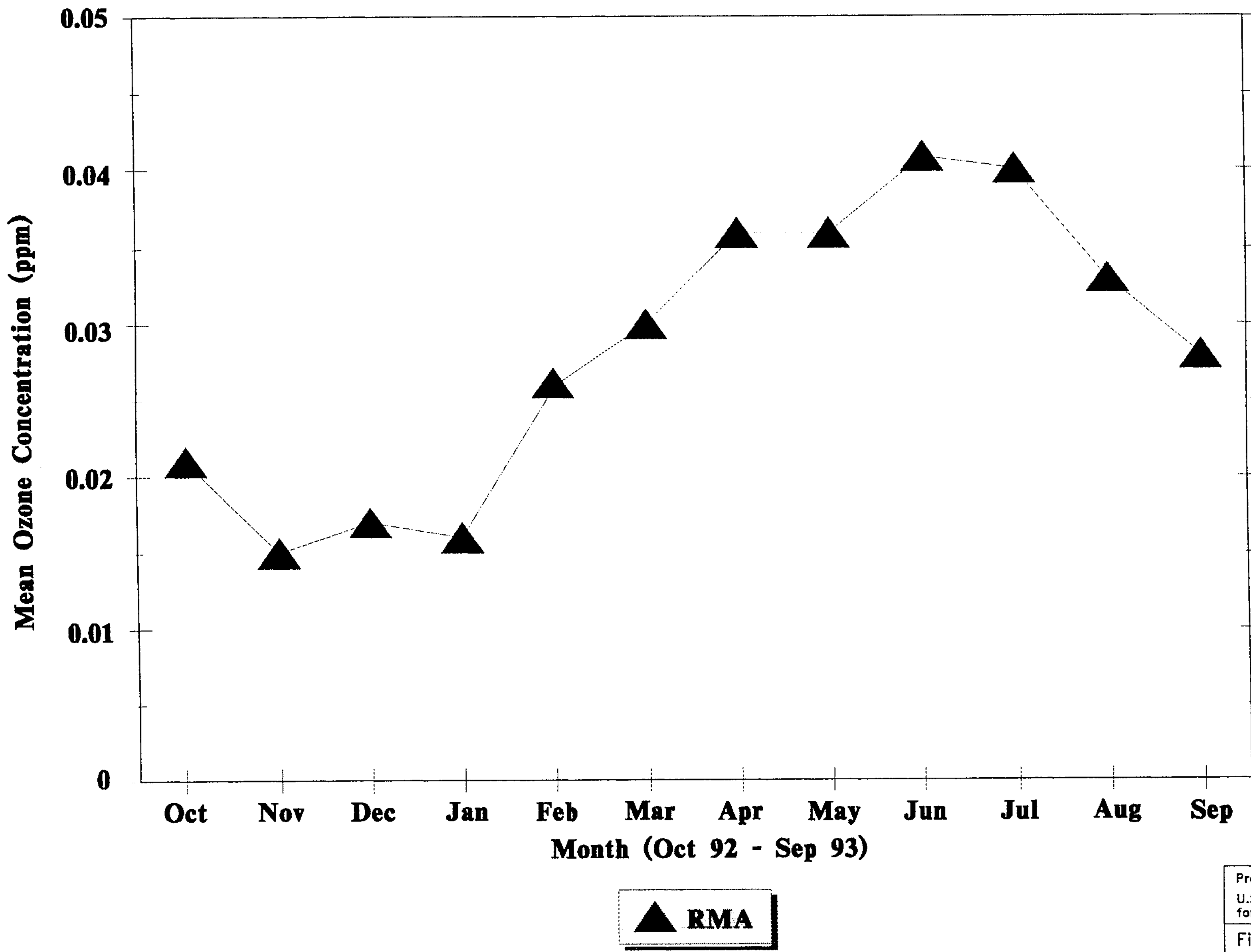

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Figure 5.4-1
RMA FY93 Monthly Mean
Ozone Concentration

Rocky Mountain Arsenal
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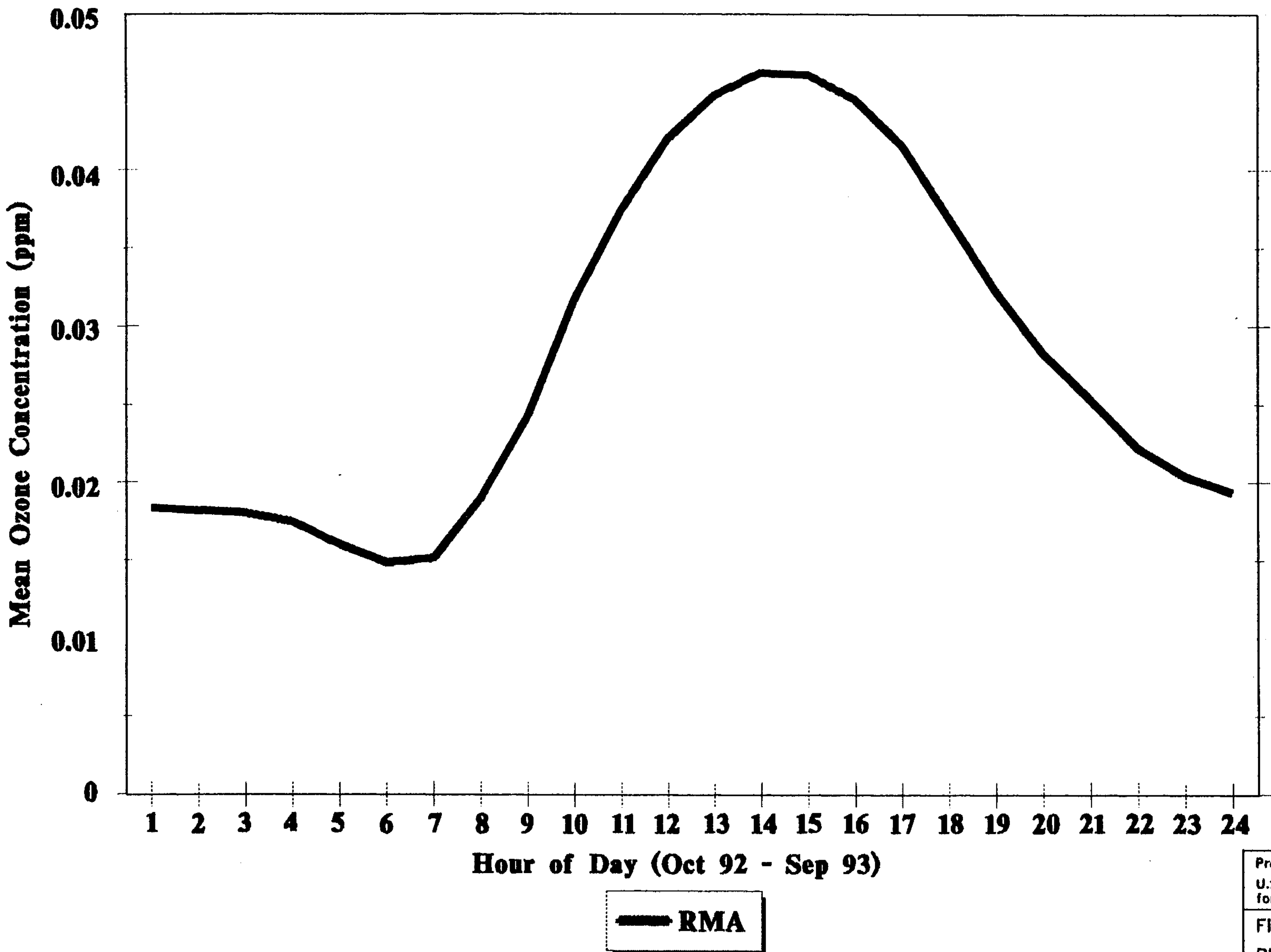

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Figure 5.4-2
RMA FY93 Diurnal Cycle for Ozone Concentration

Rocky Mountain Arsenal
Prepared by: Ebasco Services Incorporated

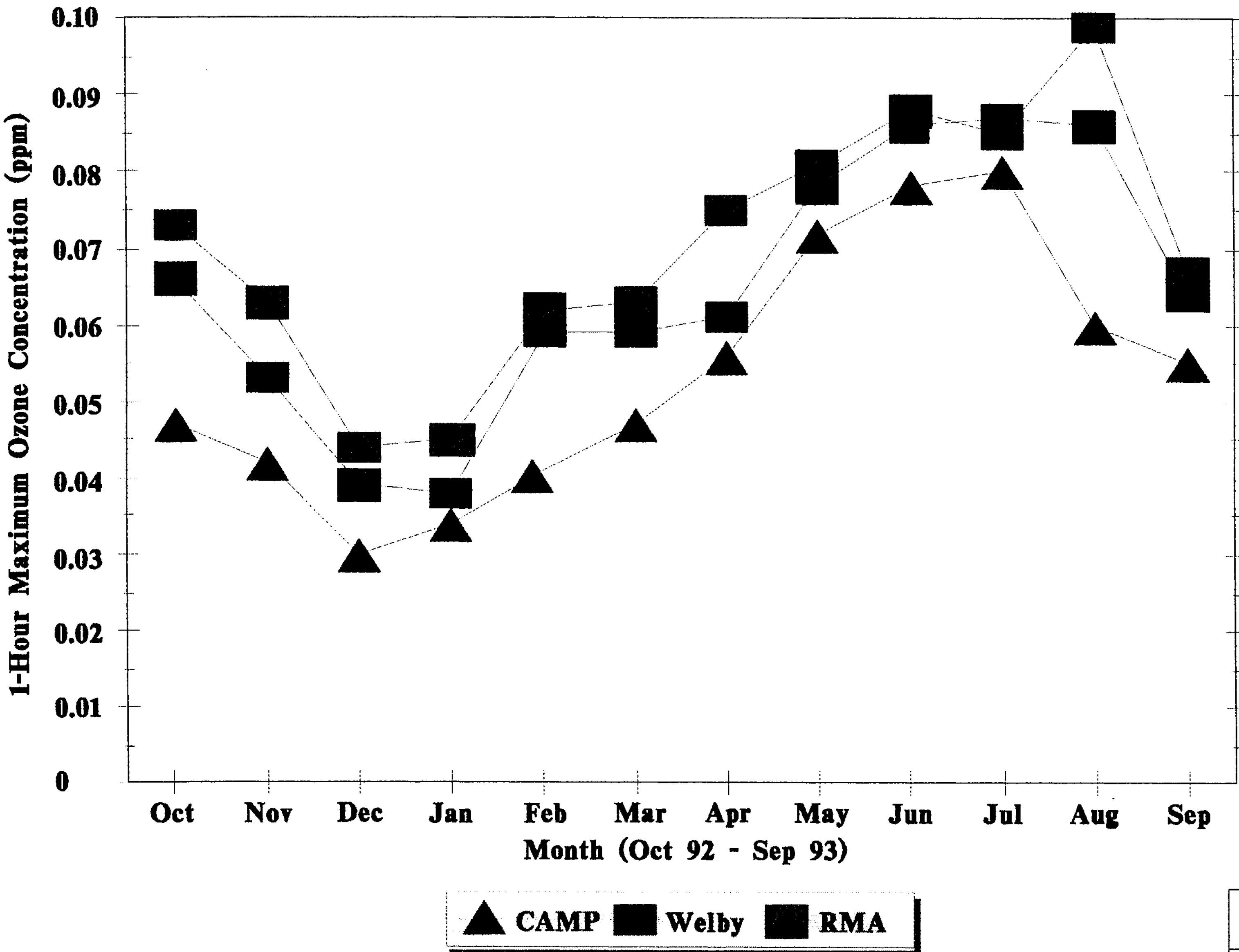

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Figure 5.4–3

FY93 Comparison of 1–Hour Maximum Ozone (concentration) for RMA and CDH Sites

Rocky Mountain Arsenal
Prepared by: Ebasco Services Incorporated

the CDH-measured concentrations. Individual graphs and tables presenting daily maximum, minimum, and mean concentrations for each month are included in Appendices I and J.

5.5 SULFUR DIOXIDE

The daily mean and maximum sulfur dioxide concentrations at the RMA site for FY93 are presented in Appendices I and J. Tables 5.5-1, 5.5-2 and 5.5-3 present monthly summaries of 1-hour, 3-hour, and 24-hour concentrations, respectively. During this data collection period, there were numerous occasions where the daily maximum concentration was several times greater than the daily mean concentration. This most likely reflects the transport of SO_2 onto RMA from metropolitan Denver SO_2 sources. There were also instances in which the daily maximum concentration was nearly the same as the daily mean concentration, reflecting periods when pollutants from metropolitan Denver were not migrating to RMA. The monthly mean concentrations were higher in the winter months when low-level inversions over metropolitan Denver are more frequent (as shown in Figure 5.5-1).

The diurnal pattern for sulfur dioxide at RMA is illustrated in Figure 5.5-2. A sharp increase in SO_2 concentrations is evident between the hours of 0600 and 1000 MST. The increase in sulfur dioxide may be caused by an increase in power generation due to greater demand for electricity during these hours, other industrial activity, or early morning inversions.

The maximum 3-hour SO_2 concentration for FY93 was 0.039 ppm, which occurred on March 18, 1993 between the hours of 1000 and 1200 MST. This concentration represents 7.8 percent of the primary 3-hour SO_2 National Ambient Air Quality Standard of 0.50 ppm and 14.4 percent of the Colorado standard of 0.27 ppm. The maximum 24-hour SO_2 concentration during FY93 at RMA was 0.015 ppm, which occurred on January 14, 1993. This concentration is 10.7 percent of the 24-hour SO_2 National Ambient Air Quality Standard of 0.14 ppm. The annual average concentration measured at RMA during FY93 was 0.002 ppm, which is 6.7 percent of the annual SO_2 National Ambient Air Quality Standard of 0.03 ppm.

Table 5.5-1 Summary of Sulfur Dioxide 1-Hour Average Values in ppm[1]: October 1, 1992 (0100 MST) through September 30, 1993 (2400 MST)

	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
Mean	0.004	0.003	0.004	0.004	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
Maximum	0.067	0.038	0.054	0.053	0.026	0.081	0.031	0.046	0.047	0.040	0.060	0.020
2nd Highest Maximum	0.036	0.038	0.048	0.052	0.017	0.034	0.017	0.030	0.039	0.030	0.022	0.018
Minimum	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Mean for Entire Period	0.002											

1 National (NAAQS) and Colorado Ambient Air Quality Standard for annual arithmetic mean is 0.030 ppm. (There is no NAAQS 1-hour standard for SO_2.)
MST Mountain Standard Time
ppm parts per million

RMA/0865 10/06/94 1:08 pm bpw

Table 5.5-2 Summary of Sulfur Dioxide 3-Hour Average Values in ppm[1]: October 1, 1992 (0100 MST) through September 30, 1993 (2400 MST)

	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
Maximum	0.029	0.031	0.035	0.029	0.013	0.039	0.018	0.026	0.025	0.024	0.027	0.015
2nd Highest Maximum	0.029	0.020	0.030	0.029	0.011	0.015	0.010	0.019	0.023	0.018	0.011	0.009

1 National Ambient Air Quality Standard for maximum 3-hour average values is 0.500 ppm, not to be exceeded more than once per year. Colorado standard for 3-hour average is 0.270 ppm.

MST Mountain Standard Time

ppm parts per million

RMA/0866 10/06/94 1:08 pm bpw

Table 5.5-3 Summary of Sulfur Dioxide 24-Hour Average Values in ppm[1]: October 1, 1992 (0100 MST) through September 30, 1993 (2400 MST)

	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
Maximum	0.011	0.008	0.015	0.015	0.004	0.007	0.004	0.006	0.005	0.004	0.004	0.004
2nd Highest Maximum	0.009	0.005	0.013	0.013	0.004	0.004	0.003	0.005	0.004	0.004	0.004	0.004

1 National Ambient Air Quality Standard for maximum 24-hour average values is 0.140 ppm, not to be exceeded more than once per year.
MST Mountain Standard Time
ppm parts per million

RMA/0867 10/06/94 1:10 pm bpw

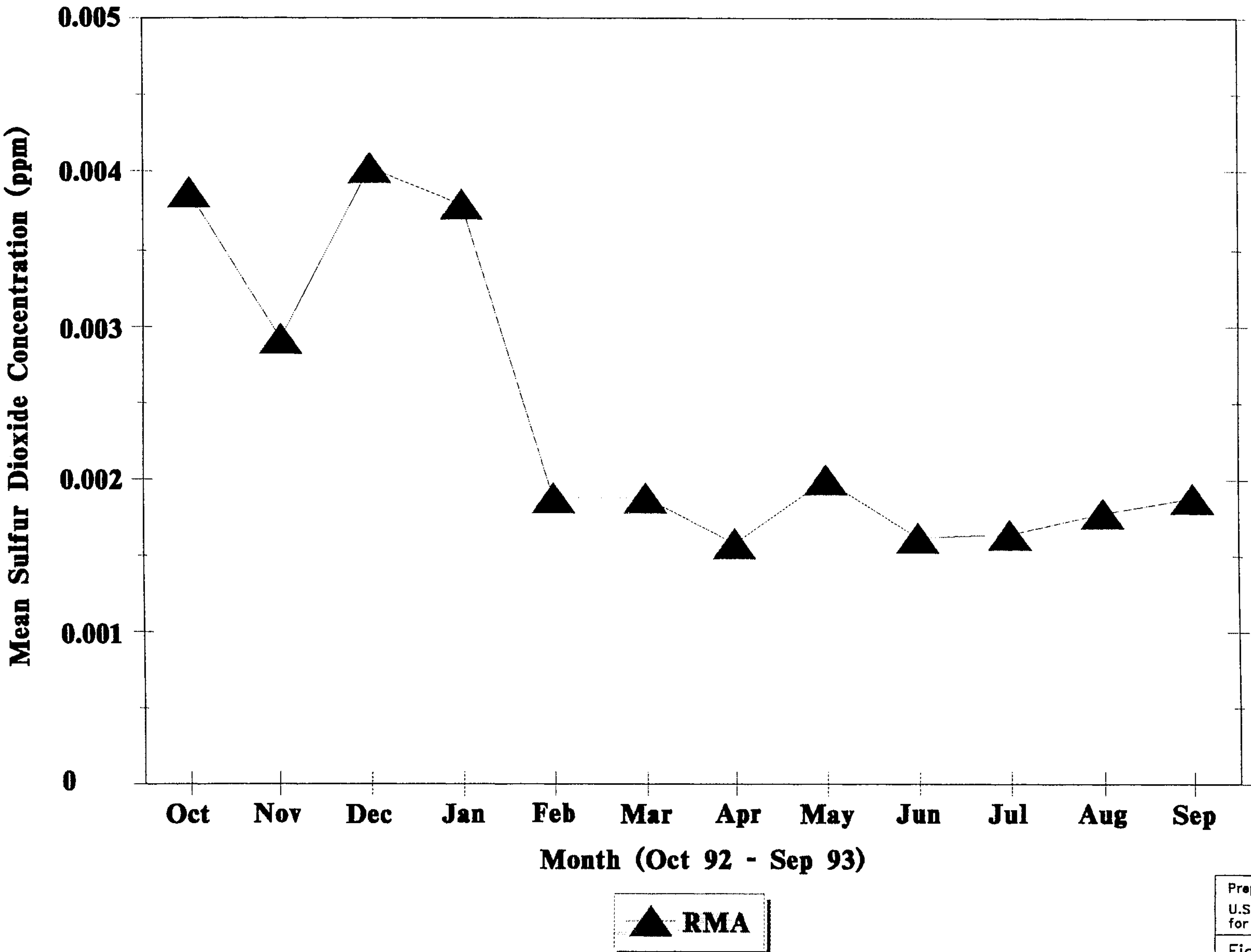

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Figure 5.5-1

RMA FY93 Monthly Mean
Sulfur Dioxide Concentration

Rocky Mountain Arsenal
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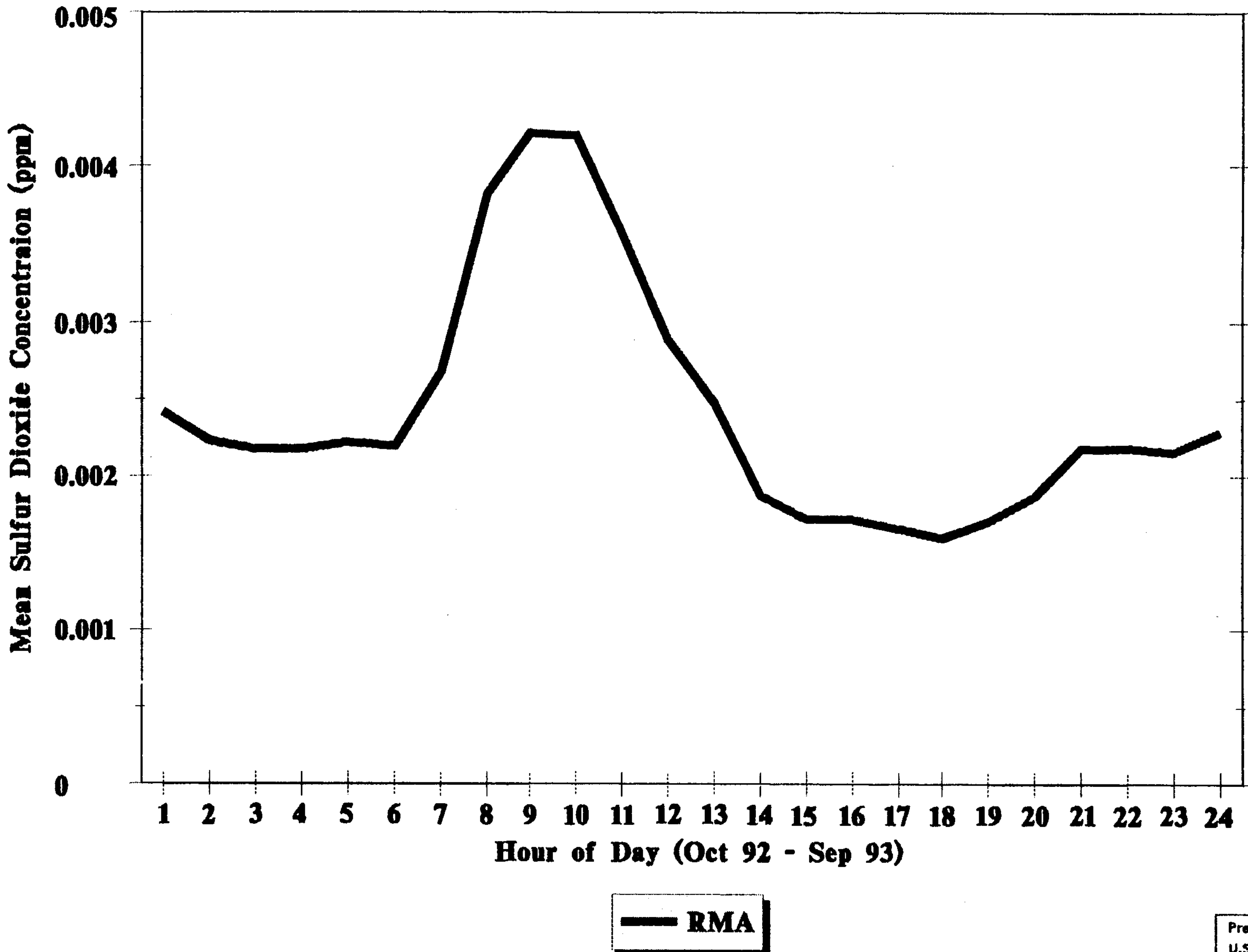

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Figure 5.5-2

RMA FY93 Diurnal Cycle for Sulfur Dioxide

Rocky Mountain Arsenal
Prepared by: Ebasco Services Incorporated

Figures 5.5-3 and 5.5-4 compare the highest 3-hour and 24-hour sulfur dioxide concentrations recorded at RMA with the two CDH sites for FY93. The RMA site recorded slightly lower values than the Welby site, and considerably lower values than the CAMP location. Individual graphs and tables presenting daily maximum, minimum, and mean concentrations for each month are provided in Appendices I and J.

5.6 NITRIC OXIDE, NITROGEN DIOXIDE, AND NITROGEN OXIDES

Daily mean concentrations for NO, NO_2, and NO_x are presented on a monthly basis in tables and graphs included in Appendices I and J. These graphs show an annual cycle for each parameter with peak concentrations most prevalent during December through February. This cycle is further illustrated in Figures 5.6-1, 5.6-2, and 5.6-3, which display mean monthly concentrations for FY93.

Monthly summaries for 1-hour average concentrations of NO, NO_2, and NO_x are given in Tables 5.6-1, 5.6-2 and 5.6-3, respectively. The National Ambient Air Quality Standard for NO_2 is 0.053 ppm and is an annual arithmetic mean. The annual mean NO_2 concentration for FY93, 0.018 ppm, represents 34 percent of the standard.

Since seasonal and diurnal trends of NO, NO_2, and NO_x are interrelated, an assessment of these three gases as a whole was made using NO_x as the indicator. The diurnal cycle for these gases illustrate a similar pattern to each other with peak concentrations between the hours of 0700 and 0900 MST, which coincided with the Denver metropolitan area morning rush-hour. For the remainder of the day, these gases exhibited their lowest concentrations, with the minimum concentration occurring at 1600 MST. NO_x concentrations then increased slightly during the late evening hours, possibly from the reformation of the surface inversion. This cycle is depicted in Figure 5.6-4. Individual graphs and tables presenting daily maximum, minimum, and mean concentrations for each day of each month are contained in Appendices I and J.

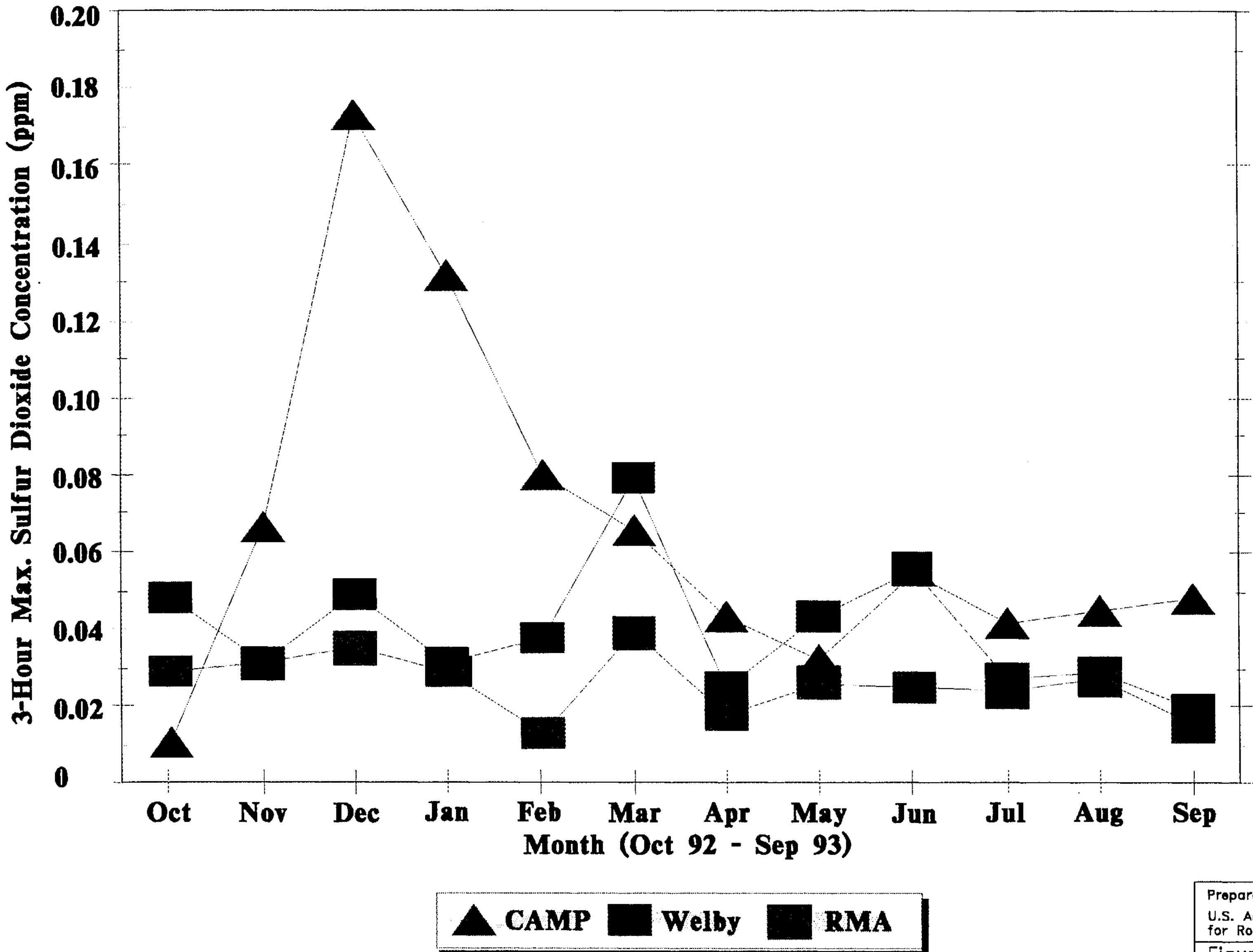

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Figure 5.5-3

FY93 Comparison of 3-Hour Maximum Sulfur Dioxide for RMA and CDH Sites

Rocky Mountain Arsenal
Prepared by: Ebasco Services Incorporated

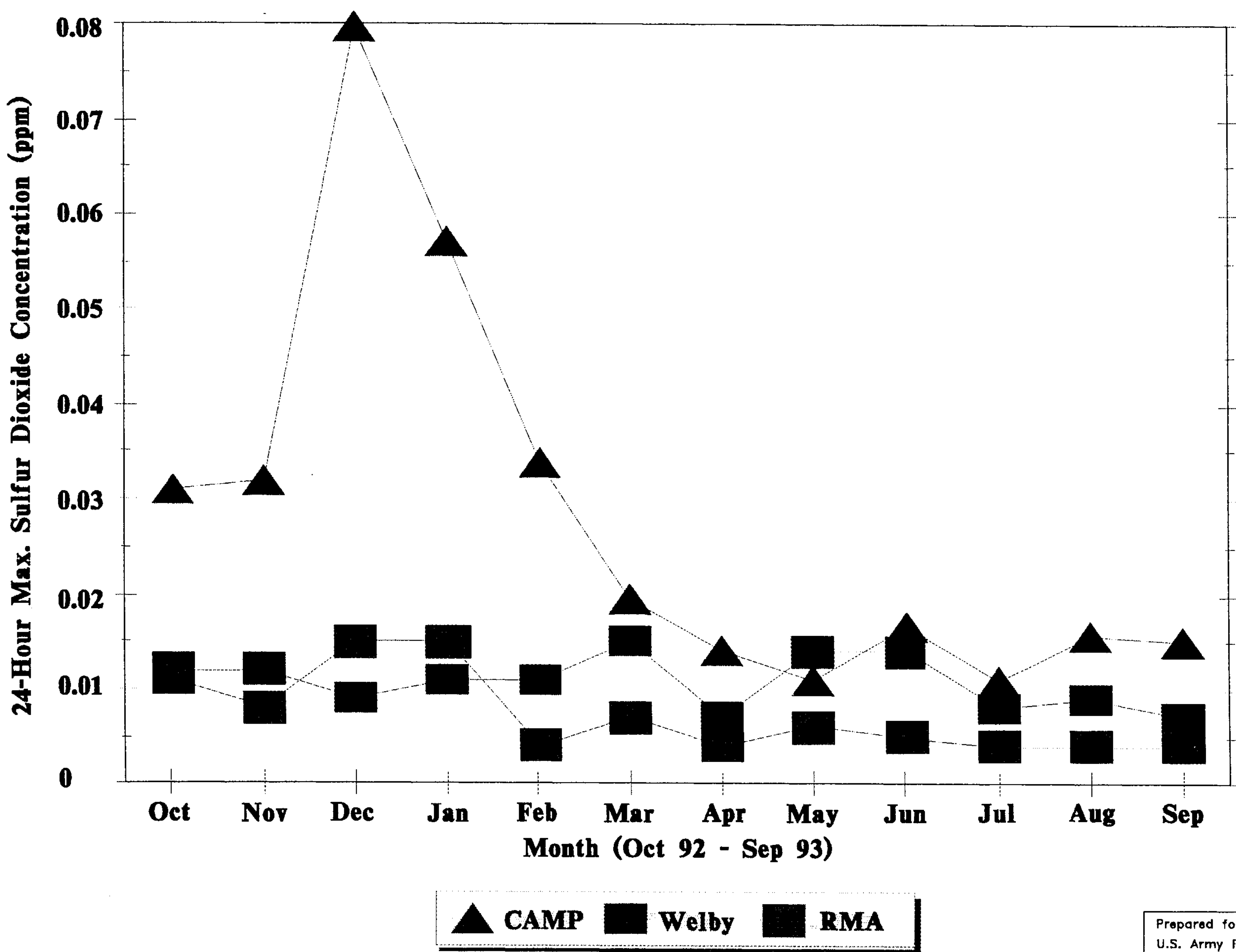

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Figure 5.5-4
FY93 Comparison of 24-Hour Maximum Sulfur Dioxide for RMA and CDH Sites

Rocky Mountain Arsenal
Prepared by: Ebasco Services Incorporated

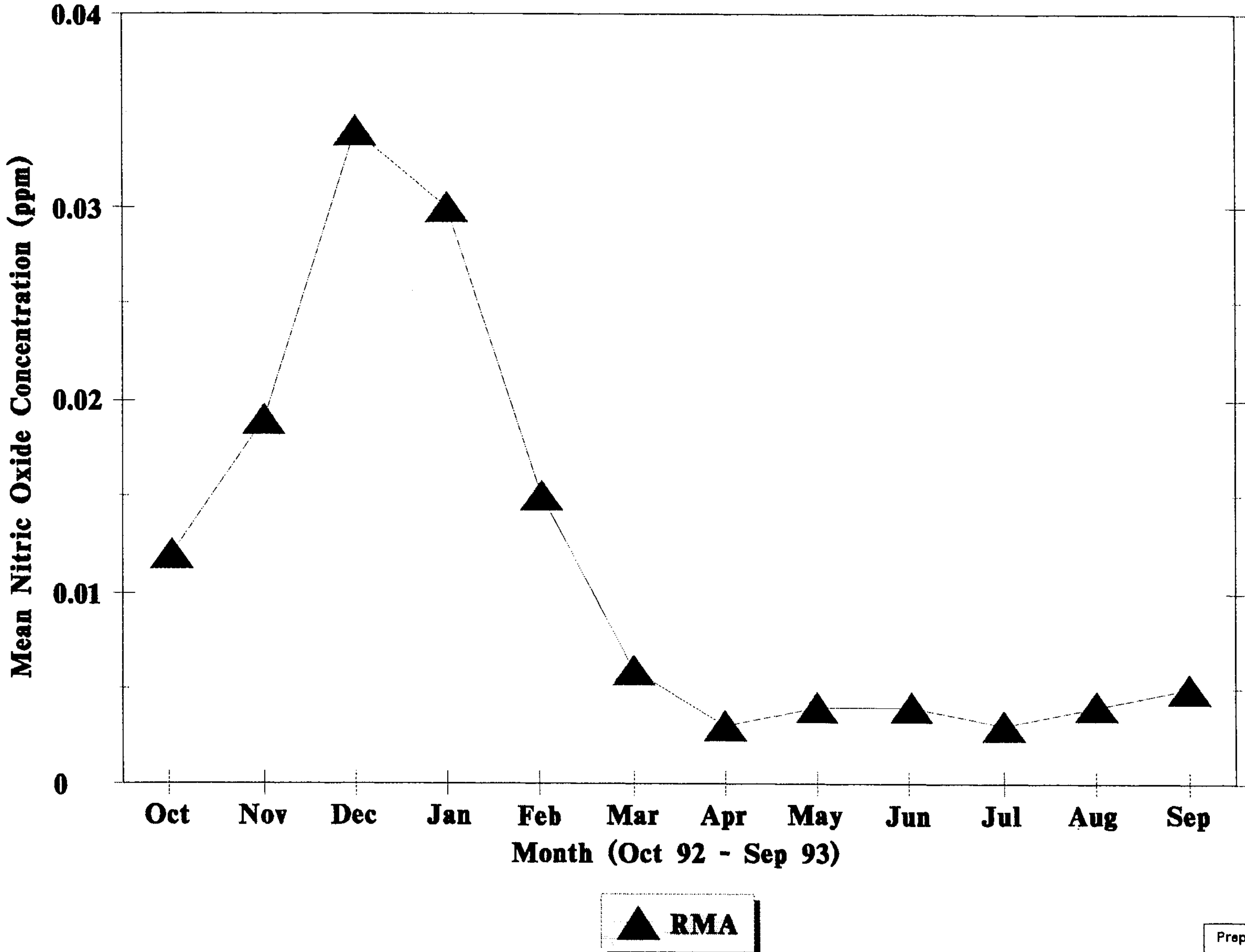

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Figure 5.6-1

RMA FY93 Monthly Mean
Nitric Oxide Concentration

Rocky Mountain Arsenal
Prepared by: Ebasco Services Incorporated

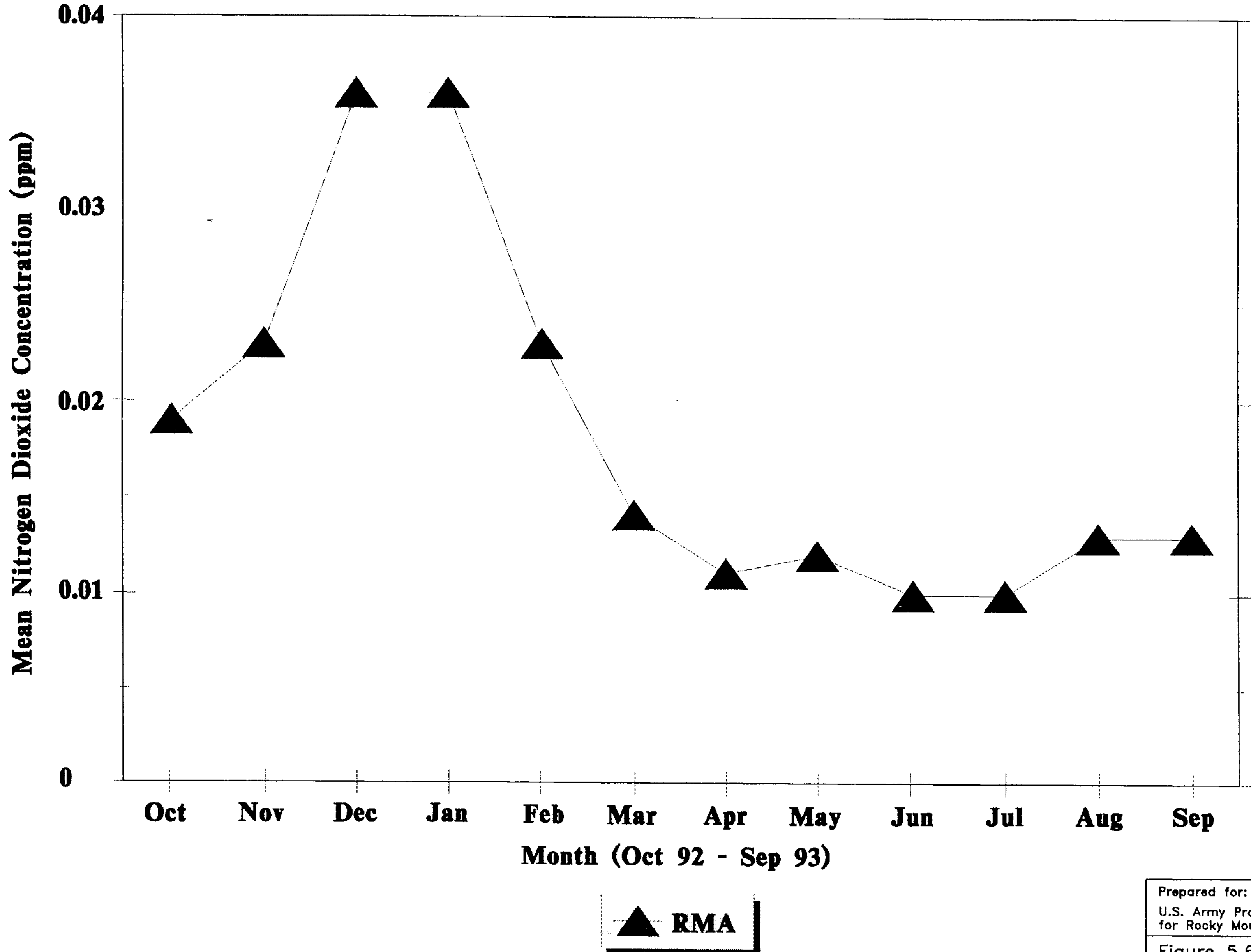

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Figure 5.6-2

RMA FY93 Monthly Mean Nitrogen Dioxide

Rocky Mountain Arsenal
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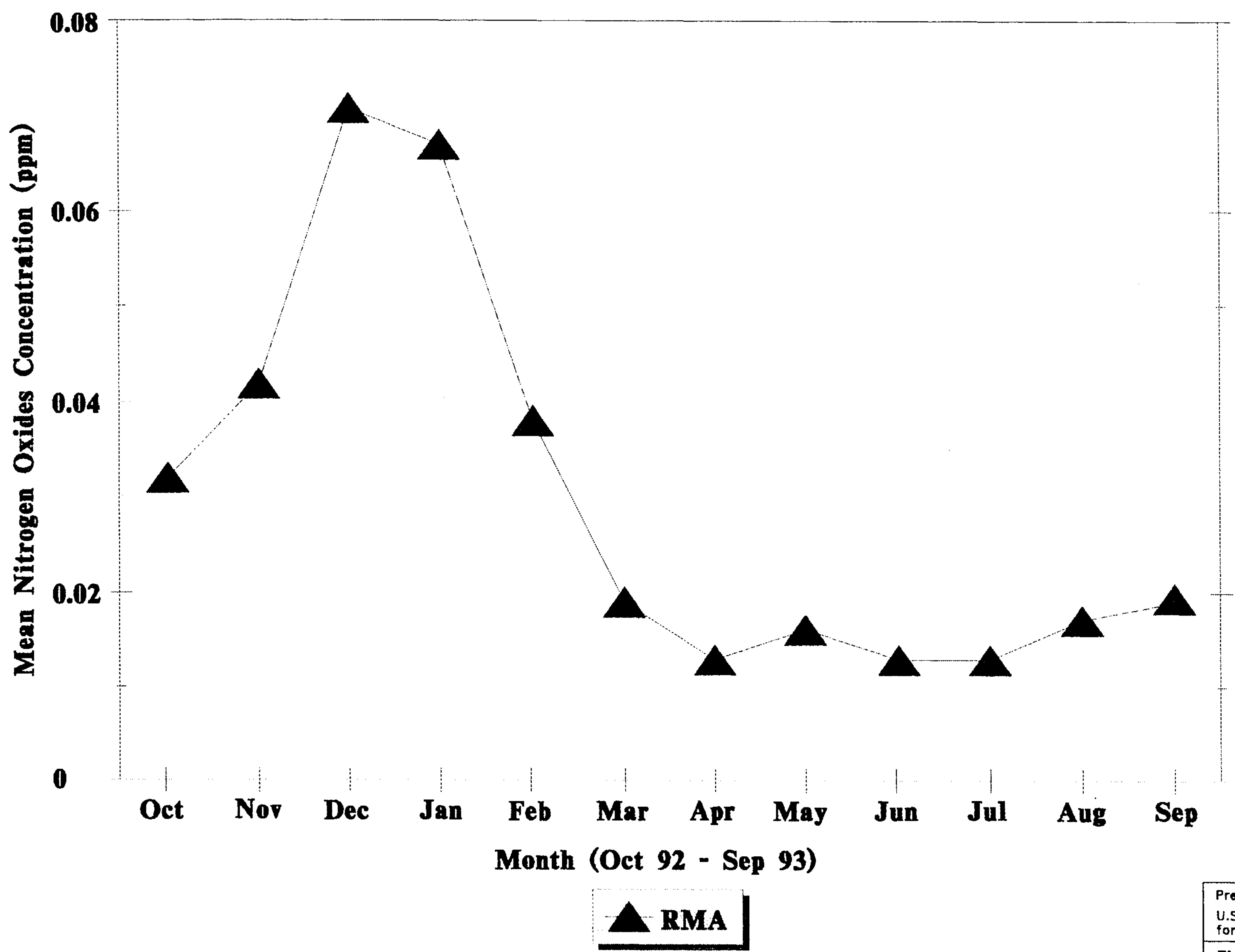

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Figure 5.6-3

RMA FY93 Monthly Mean Nitrogen Oxides

Rocky Mountain Arsenal
Prepared by: Ebasco Services Incorporated

Table 5.6-1 Summary of Nitric Oxide 1-Hour Average Values in ppm: October 1, 1992 (0100 MST) through September 30, 1993 (2400 MST)

	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
Mean	0.012	0.019	0.034	0.030	0.015	0.006	0.003	0.004	0.004	0.003	0.004	0.005
Maximum	0.184	0.202	0.317	0.387	0.271	0.142	0.074	0.103	0.084	0.044	0.048	0.088
2nd Highest Maximum	0.170	0.171	0.302	0.327	0.242	0.113	0.072	0.085	0.064	0.037	0.040	0.077
Minimum	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Mean for Entire Period	0.011											

MST Mountain Standard Time
ppm parts per million

RMA/0868 10/06/94 1:11 pm bpw

Table 5.6-2 Summary of Nitrogen Dioxide 1-Hour Average Values in ppm[1]: October 1, 1992 (0100 MST) through September 30, 1993 (2400 MST)

	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
Mean	0.019	0.023	0.036	0.036	0.023	0.014	0.011	0.012	0.010	0.010	0.013	0.013
Maximum	0.062	0.099	0.140	0.178	0.113	0.076	0.066	0.069	0.066	0.082	0.064	0.055
2nd Highest Maximum	0.061	0.094	0.132	0.170	0.110	0.075	0.056	0.056	0.058	0.066	0.044	0.055
Minimum	0.001	0.001	0.002	0.004	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Mean for Entire Period	0.018											

1 National and Colorado Ambient Air Quality Standard for annual arithmetic mean is 0.053 ppm.
MST Mountain Standard Time
ppm parts per million

Table 5.6-3 Summary of Nitrogen Oxides 1-Hour Average Values in ppm[1]: October 1, 1992 (0100 MST) through September 30, 1993 (2400 MST)

	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
Mean	0.032	0.042	0.071	0.067	0.038	0.019	0.013	0.016	0.013	0.013	0.017	0.019
Maximum	0.234	0.271	0.442	0.525	0.371	0.218	0.124	0.154	0.119	0.088	0.082	0.140
2nd Highest Maximum	0.216	0.255	0.423	0.466	0.353	0.188	0.116	0.140	0.099	0.086	0.082	0.113
Minimum	0.001	0.001	0.002	0.005	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Mean for Entire Period	0.030											

MST Mountain Standard Time
ppm parts per million

RMA/0871 10/06/94 1:12 pm bpw

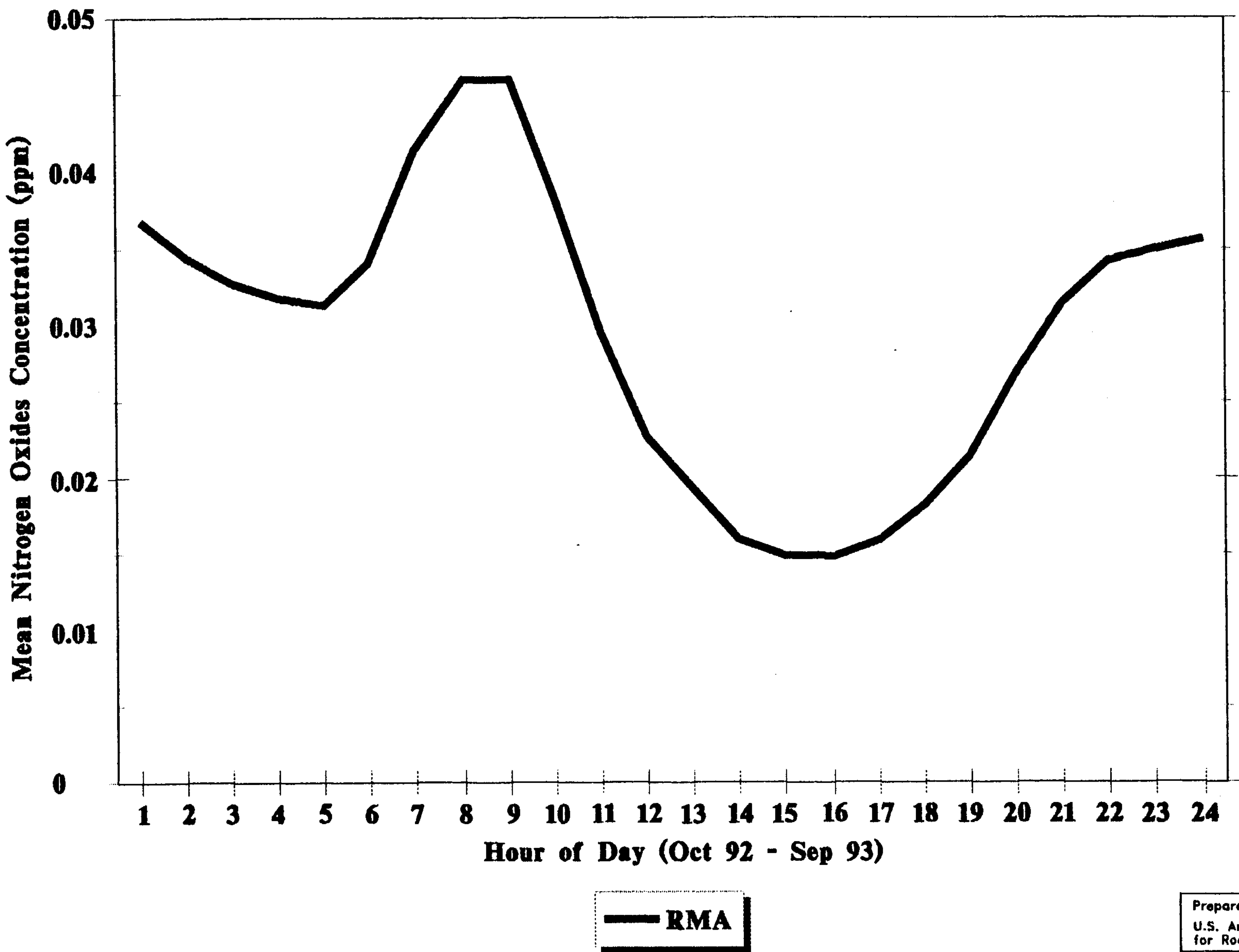

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Figure 5.6-4

RMA FY93 Diurnal Cycle for Nitrogen Oxides

Rocky Mountain Arsenal
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Several case studies are presented in the next section to show the interaction between metropolitan Denver source emissions, meteorological conditions, and ambient concentrations measured at RMA.

5.7 REGIONAL EMISSION SOURCES IMPACTING RMA

Tables 5.7-1 through 5.7-3 provide listings of criteria pollutant emissions (carbon monoxide, sulfur dioxide, and nitrogen oxides) from major metropolitan Denver industrial sources. Ozone is not emitted directly from a source as are other pollutants, but forms as a secondary pollutant. Its precursors are certain reactive hydrocarbons and nitrogen oxides, which react chemically with each other in sunlight (CDH 1991). Those sources listed in Tables 5.7-1 through 5.7-3 can therefore be considered as contributors to ozone production.

In addition to stationary sources, automobile exhaust is a principal precursor of ozone. In the winter, automobile emissions produce 86 percent of the carbon monoxide (CO) measured in Denver and about 33 percent of the NO_x (CDH 1989). Both stationary and mobile emissions (primarily from vehicle traffic) jointly contribute to the ambient air quality conditions measured at RMA. Note that the RMA gaseous emission sources are quite small compared to the significant major sources in the Denver area, as shown in Tables 5.7-1 through 5.7-3.

Figures 5.7-1 through 5.7-3 show the distribution of stationary sources surrounding RMA (source locations are cross-referenced in Tables 5.7-1 through 5.7-3). Most of the sources are to the south and southwest of RMA, where the major vehicle activity also occurs. Monitoring results from the RMA station showed levels of CO, SO_2, and NO_x that were generally below metropolitan Denver monitoring values. However, when prevailing winds associated with a strong inversion blew in the direction of RMA, external sources significantly impacted RMA air quality.

A review of the air quality and meteorological data for RMA during FY93 indicates a number of probable pollution migration episodes onto RMA. Case studies for TSP, PM-10, metals, and

Table 5.7-1 Sources in the Metropolitan Denver Area Ranked by Reported Emissions of Carbon Monoxide

[Sources with emissions greater than 1 ton per year (tpy)]

Facility	City	Update Year	Map No.	Estimate (tpy)	
Public Service Co. - Cherokee Plant	Denver	91	a	550.0	(1)
Colorado Interstate Gas Co. - Watkins Station	Watkins	91	1	335.0	
Conoco Inc. Denver Refinery	Commerce City	91	b	272.0	(1)
Public Service Co. - Arapahoe Plant	Denver	91	c	160.0	(1)
Colorado Refining Co.	Commerce City	91	d	141.0	(1)
Metro Wastewater Reclamation District	Denver	91	2	83.8	
Koch Hydrocarbon Co. Third Creek Plant	Brighton	92	3	65.2	
Buckley ANG Base - Colo. Air Nat'l Guard	Aurora	91	4	56.0	
Owens-Corning Fiberglas Corp-Trumbull	Denver	92	5	41.5	
Public Service Company - Delganey	Denver	91	6	22.7	
Koch Hydrocarbon Co. Mitchell Station	Byers	92	7	22.3	
Koch Hydrocarbon Co. - Radar Plant	Commerce City	92	8	19.4	
Koch Hydrocarbon Co. - Dragoon Station	Bennett	92	9	18.6	
Explosive Fabricators Inc	Englewood	80	10	16.7	
Brannan S & G	Denver	90	11	16.1	
Colorado Interstate Gas Company Latigo	Watkins	91	12	16.0	
Bar S Foods Company	Denver	92	13	15.2	
Koch Hydrocarbon Co. - Boxelder Station	Denver	92	14	14.6	
Presbyterian/St. Lukes Healthcare	Denver	90	15	13.6	
Littleton/Englewood WWTP	Englewood	92	16	10.7	
Public Service Company - Zuni	Denver	92	17	10.5	
Koch Hydrocarbon Co. Rattlesnake Station	Bennett	92	18	9.6	
ITT Continental Baking Company 80 E 62nd	Denver	90	19	9.3	
Schafer Commercial Seating Inc	Denver	92	20	8.6	
Panhandle Eastern Pipe Line Co. Brighton	Brighton	92	21	8.6	
Lowry AFB	Denver	90	22	8.5	
Koch Hydrocarbon Co. - Antelope station	Bennett	92	23	8.5	
Irondale Gas Processing Co. Irondale	Brighton	92	24	7.9	
Sinclair Oil Denver Product Terminal	Henderson	92	25	7.6	
Univ of Colo Health Sciences Center	No City Name	90	26	7.2	
Sand Creek Chemical	Commerce City	92	27	7.1	
Rocky Mountain Arsenal - Dept of Army	Commerce City	92	28	7.0	
Ralston Purina Company Pet Food Plant	Denver	92	29	6.9	
Fitzsimons Army Hospital	Aurora	90	30	6.8	
Republic Paperboard Company	Commerce City	92	31	6.6	
AT&T Information Systems	Westminster	90	32	6.0	
The Childrens Hospital	Denver	92	33	4.2	
Robinson Brick #2	Denver	90	34	4.1	
National By-products, Inc	Denver	92	35	4.0	
Koch Hydrocarbon Co. - Kallsen Plant	Watkins	92	36	3.9	

Emissions estimates obtained from EPA Aerometric Information Retrieval System.

(1) Emissions based on February, 1993 data (as presented in FY92 Data Report)

Table 5.7-1 Sources in the Metropolitan Denver Area Ranked by Reported Emissions of Carbon Monoxide

[Sources with emissions greater than 1 ton per year (tpy)]

Facility	City	Update Year	Map No.	Estimate (tpy)
Denver and Rio Grande Western RR	Denver	90	37	3.7
US West 12121 Grant	No City name	90	38	3.5
St Joseph Hospital	Denver	90	39	3.5
Sfuzzi VII Denver Inc.	no City Name	90	40	3.5
Koch Hydrocarbon Co. - State Plant	Watkins	92	41	3.5
PepCol Manufacturing Company	Denver	90	42	3.4
Keebler Company	Denver	92	43	3.3
Radison Hotel Denver	Denver	92	44	3.2
BFI - Tower Landfill	Commerce City	92	45	3.1
AG - Power of Colorado	Denver	90	46	2.9
Presbyterian Medical Center	Denver	90	47	2.7
Central Products Co.	Brighton	91	48	2.7
RustCo Products Co.	Denver	91	49	2.5
U.S. West	No City Name	90	50	2.4
Owens Corning	Denver	92	51	2.2
Bituminous Roadways of Co, Inc.	Commerce City	92	52	2.1
Swedish Medical Center	Englewood	91	53	2.0
Provenant Healthcare Partners	Denver	92	54	2.0
City and County of Denver - Stapleton Airport	Denver	90	55	1.8
Safeway Milk Plant	Denver	92	56	1.7
Rocky Mountain Prestress	Denver	92	57	1.7
Koch Hydrocarbon Co. Texaco Station	Bennett	92	58	1.6
Denver General Hospital	Denver	88	59	1.6
Western Paving Const.Co.-North Plant	Denver	92	60	1.5
Denver Public Schools - Kepner Jr High	No City Name	87	61	1.5
Rocky Mtn Dyeing & Finishing	Denver	89	62	1.4
Red Seal Inc.	Denver	90	63	1.4
Metrum Information Storage	Littleton	92	64	1.4
Denver Public Schools - Abraham Lincoln	No City Name	83	65	1.4
The Electron Corporation	Littleton	91	66	1.3
VA Hospital Denver	Denver	88	67	1.2
United Airlines	Denver	89	68	1.2
Humana Hospital Mt View	Thornton	89	69	1.2
Dow Chemical USA	Aurora	92	70	1.2
Packaging Corp. of America	Commerce City	92	71	1.1
Koppers Co	Adams Co	88	72	1.1
Gardner-Denver	Denver	90	73	1.0

Emissions estimates obtained from EPA Aerometric Information Retrieval System.

(1) Emissions based on February, 1993 data (as presented in FY92 Data Report)

Table 5.7-2 Sources in the Metropolitan Denver Area Ranked by Reported Emissions of Sulfur Dioxide

[Sources with emissions greater than 1 ton per year (tpy)]

Facility	City	Update Year	Map No.	Estimate (tpy)
Public Service Company - Cherokee	Denver	91	1	13362.3
Public Service Company - Arapahoe	Denver	91	2	4567.0
Conoco Inc. - Denver Refinery	Commerce City	91	3	2336.1
Colorado Refining Company / Total Petroleum	Commerce City	91	4	631.7
Metro Wastewater Reclamation District	Denver	91	5	134.0
Buckley ANG Base - Colo. Air Nat'l Guard	Aurora	91	6	37.1
Owens-Corning Fiberglas Corp	Denver	92	7	28.7
General Chemical Corporation 1271 W Bayaud	Denver	90	8	28.0
The Gates Rubber Co.	Denver	90	9	27.9
Bar S Foods Company	Denver	92	10	25.0
Fast Construction Company 64th and Steel	Commerce City	90	11	24.6
Amoco Production Co. - Wattenberg Plant	Watkins	92	12	23.5
Asarco Incorporated - Globe Plant	Denver	91	13	17.5
Kiewit Western	Portable	90	14	15.9
Brannan S & G	Denver	90	15	15.5
Western Paving Const.Co.-North Plant	Denver	92	16	8.8
Milt Adams Inc Custom Refining	Aurora	88	17	8.7
Colorado Special Chemical Inc Commerce City	Westminster	90	18	8.0
National Smelting and Refining Company	Commerce City	90	19	7.2
Northwestern Engineering 6001 Dexter	Commerce City	90	20	6.2
Rocky Mountain Arsenal - Dept of Army	Commerce City	92	21	6.0
Quikrete Colorado	Denver	90	22	5.9
OEA Inc.	Aurora	90	23	5.2
Univ of Colo Health Sciences Center	No City Name	90	24	3.8
Duwald Steel Corporation	Denver	92	25	2.2
Public Service Company - Zuni	Denver	92	26	1.8
Rocky Mountain Prestress	Denver	92	27	1.4
BFI - Tower Landfill	Commerce City	92	28	1.2
U.S. West	No City Name	90	29	1.0
U.S. West	No City Name	90	30	1.0

Emission estimates obtained from EPA Aerometic Information Retrieval Information.

Table 5.7-3 Sources in the Metropolitan Denver Area Ranked by Reported Emissions of Nitrogen Dioxide

[Sources with emissions greater than 5 tons per year (tpy)]

Facility	City	Update Year	Map No.	Estimate (tpy)
Public Service Company - Cherokee	Denver	91	1	14295.2
Public Service Company - Arapahoe	Denver	91	2	5143.3
Colorado Interstate Gas Co - Watkins Station	Watkins	91	3	865.5
Conoco Inc. - Denver Refinery	Commerce City	91	4	625.8
Amoco Production Co. - Wattenberg Plant	Watkins	92	5	548.7
Koch Hydrocarbon Co. Third Creek Plant	Brighton	92	6	503.7
Public Service Company - Delganey	Denver	91	7	313.3
Colorado Refining Company / Total Petroleum	Commerce City	91	8	287.5
Buckley ANG Base - Colo. Air Nat'l Guard	Aurora	91	9	263.1
The Gates Rubber Co.	Denver	90	10	215.2
Koch Hydrocarbon Co. Mitchell Station	Byers	92	11	175.8
Koch Hydrocarbon Co. - Radar Plant	Commerce City	92	12	153.3
Koch Hydrocarbon Co. - Dragoon Station	Bennett	92	13	146.2
Public Service Company - Zuni Station	Denver	92	14	145.6
Colorado Interstate Gas Company Latigo	Watkins	91	15	125.8
Koch Hydrocarbon Co. - Boxelder Station	Denver	92	16	115.0
Gulf Energy Development Chalice Plant	Aurora	90	17	96.0
Presbyterian/St. Lukes Healthcare	Denver	90	18	91.6
Littleton/Englewood WWTP	Englewood	92	19	80.4
Koch Hydrocarbon Co. Rattlesnake Station	Bennett	92	20	75.5
Panhandle Eastern Pipe Line Co. Brighton	Brighton	92	21	68.4
Koch Hydrocarbon Co. - Antelope Station	Bennett	92	22	67.3
Irondale Gas Processing Co. Irondale	Brighton	92	23	62.9
Metro Wastewater Reclamation District	Denver	91	24	48.0
ITT Continental Baking Company 80 E 62nd	Denver	90	25	46.7
Lowry AFB	Denver	90	26	38.8
Rocky Mountain Arsenal - Dept of Army	Commerce City	92	27	32.6
Koch Hydrocarbon Co. - Kallsen Plant	Watkins	92	28	31.2
Univ of Colo Health Sciences Center	No City Name	90	29	30.6
Ralston Purina Company Pet Food Plant	Denver	92	30	30.6
Owens-Corning Fiberglas Corp-Trumbull	Denver	92	31	28.7
Koch Hydrocarbon Co. - State Plant	Watkins	92	32	27.9
Fitzsimons Army Hospital	Aurora	90	33	27.3
Koch Hydrocarbon Co Denver Central Plant	Strasburg	92	34	27.2
Republic Paperboard Company	Commerce City	92	35	26.6
AT&T Info. Systems	Westminster	90	36	24.1
Western Paving Const.Co.-North Plant	Denver	92	37	23.9
Sand Creek Chemical	Commerce City	92	38	23.5
Kiewit Western	Portable	90	39	19.0
Bar S Foods Company	Denver	92	40	18.8
The Childrens Hospital	Denver	92	41	18.5

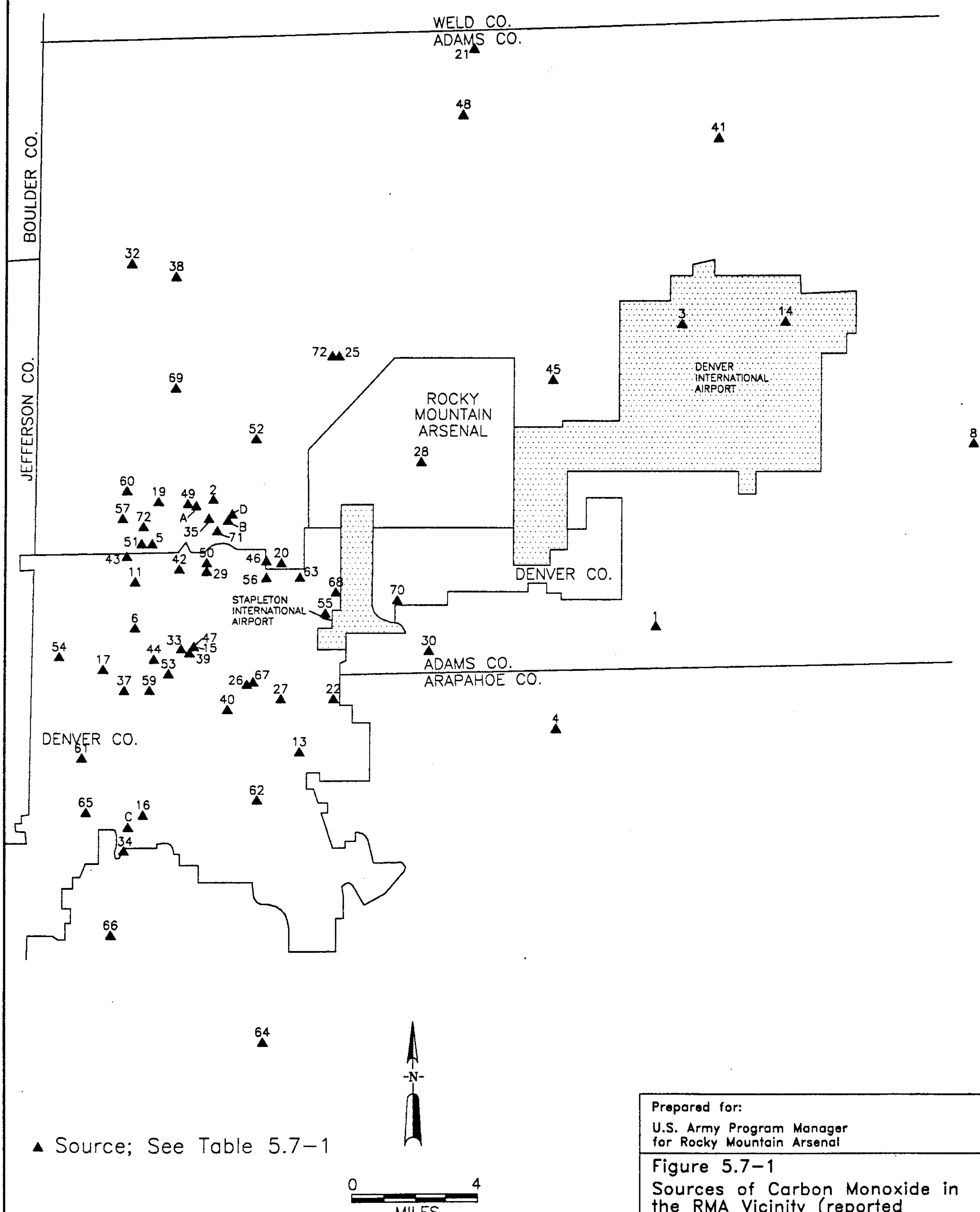
Emission estimates obtained from EPA Aerometric Information Retrieval System

Table 5.7-3 Sources in the Metropolitan Denver Area Ranked by Reported Emissions of Nitrogen Dioxide

[Sources with emissions greater than 5 tons per year (tpy)]

Facility	City	Update Year	Map No.	Estimate (tpy)
US West	No City Name	90	42	16.4
Denver and Rio Grande Western RR	Denver	90	43	14.9
Pepcol Manufacturing Company	Denver	90	44	14.7
St Joseph Hospital	Denver	90	45	14.0
National By-Products, Inc	Denver	92	46	14.0
Keebler Company	Denver	92	47	13.5
Koch Hydrocarbon Co. Texaco Station	Bennett	92	48	13.1
Radison Hotel Denver	Denver	92	49	12.8
Robinson Brick #2	Denver	90	50	12.3
AG - Power of Colorado	Denver	90	51	11.7
U.S. West	No City Name	90	52	11.1
Rustco Products Co.	Denver	91	53	11.0
Central Products Co.	Brighton	91	54	11.0
Presbyterian Medical Center	Denver	90	55	10.9
Brannan S & G	Denver	90	56	8.5
Provenant Healthcare Partners	Denver	92	57	8.2
Swedish Medical Center	Englewood	91	58	8.0
Frito Lay Inc	Denver	89	59	7.6
City and County of Denver Stapleton Field	Denver	90	60	7.5
Rocky Mountain Dyeing & Finishing	Denver	89	61	7.2
Rocky Mountain Prestress	Denver	92	62	7.2
Metrum Information Storage	Littleton	92	63	7.2
The Electron Corporation	Littleton	91	64	7.1
Safeway Milk Plant	Denver	92	65	7.0
Western Gas Processors Ltd	Commerce City	90	66	6.8
Denver General Hospital	Denver	88	67	6.7
Bituminous Roadways of Co, Inc.	Commerce City	92	68	6.4
VA Hospital Denver	Denver	88	69	6.3
DPS - Kepner Jr	No City Name	87	70	6.3
Dow Chemical USA	Aurora	92	71	6.3
Red Seal Inc	Denver	90	72	5.8
BFI - Tower Landfill	Commerce City	92	73	5.8
United Airlines 36th & Syracuse	Denver	89	74	5.5
Vessels Oil & Gas Co. - Radar Comp. Sta.	Brighton	92	75	5.1

Emission estimates obtained from EPA Aerometric Information Retrieval System



Prepared for:

U.S. Army Program Manager
for Rocky Mountain Arsenal

Figure 5.7-1
Sources of Carbon Monoxide in the RMA Vicinity (reported emissions >1 tpy)

Rocky Mountain Arsenal
Prepared by: Ebasco Services Incorporated

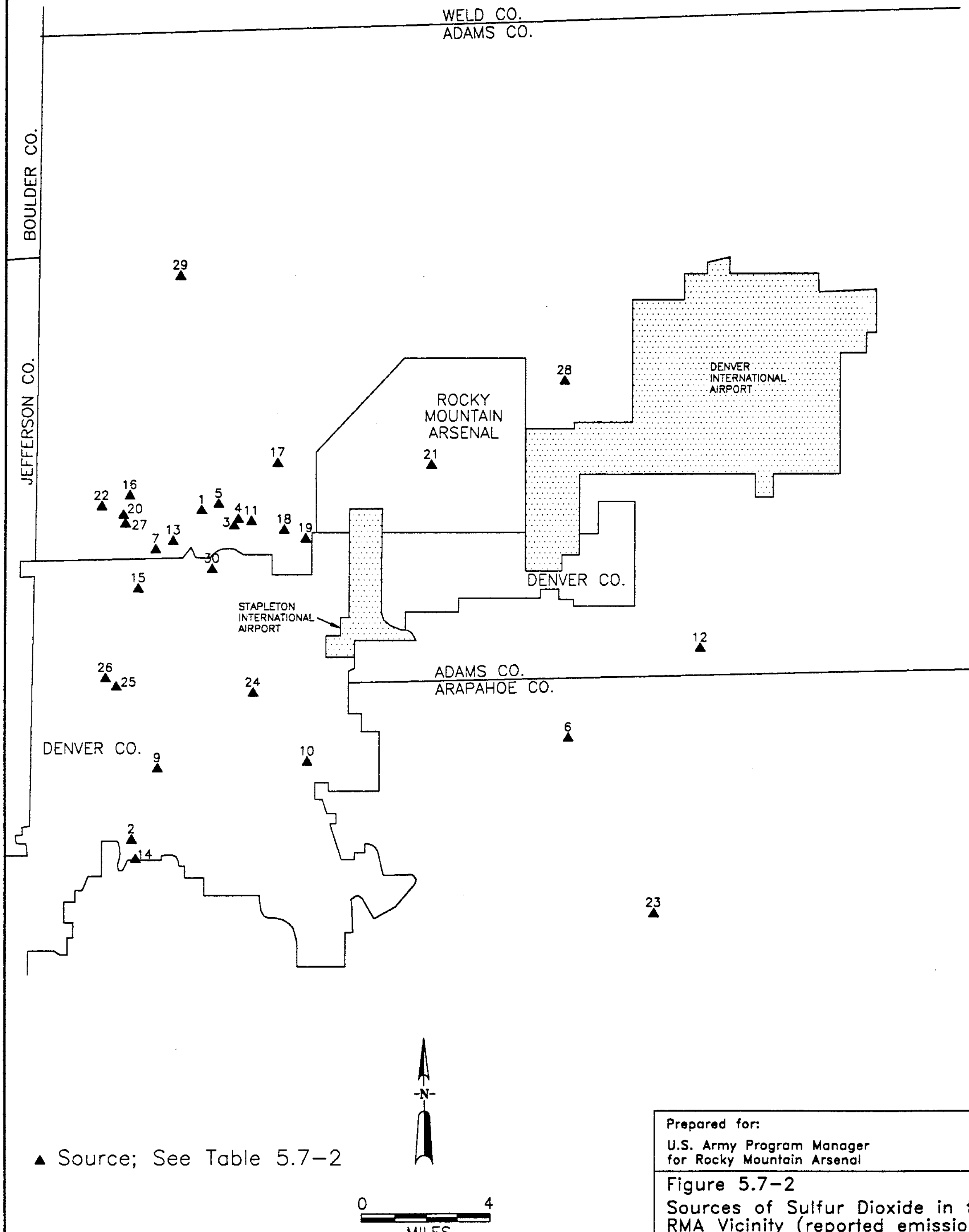


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Figure 5.7-2

Sources of Sulfur Dioxide in the RMA Vicinity (reported emissions >25 tpy)

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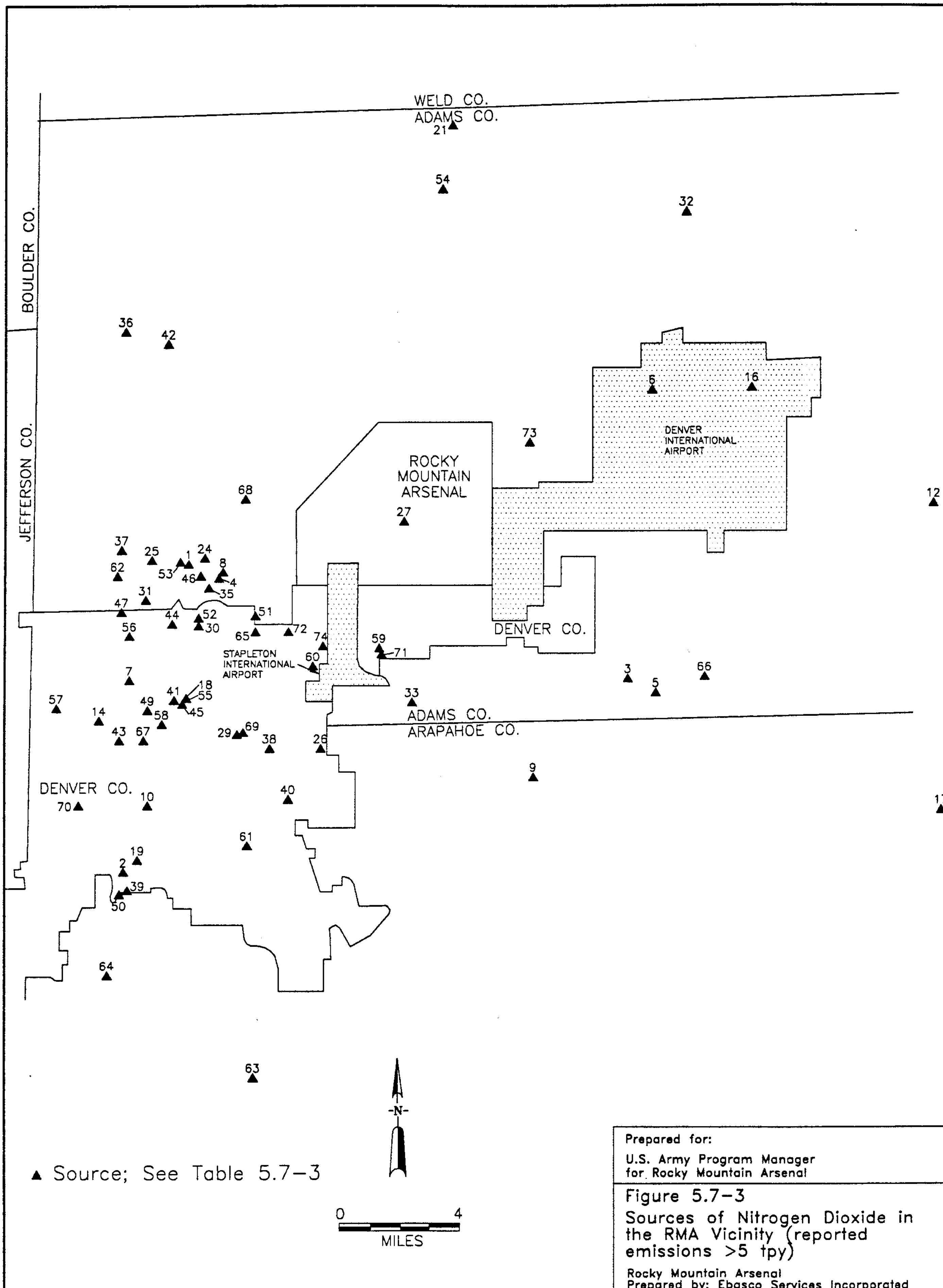

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Figure 5.7-3

Sources of Nitrogen Dioxide in the RMA Vicinity (reported emissions >5 tpy)

Rocky Mountain Arsenal
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VOCs have been discussed in prior sections of this report. As noted, in the Tri-County area of Adams, Arapahoe, and Denver counties, there were a number of NO_x, CO, and SO_2 point sources and mobile sources that contributed to the RMA background air quality. As was the case with metropolitan Denver, the poorest air quality days at RMA were associated with the existence of intense ground-level inversions over the area and the subsequent development of the so-called brown cloud phenomenon. When this layer of industrial pollution drifted over RMA either directly or circuitously (after a wind shift), RMA recorded its highest levels for almost all pollutants measured. In the case of TSP, PM-10, metals, and VOCs, it was necessary to distinguish between potential local RMA sources and external sources. However, since emissions of criteria gaseous pollutants are minimal at RMA, a clear record of these incursions was provided by the meteorological and gaseous monitored data collected at RMA. Some examples are illustrated below.

5.7.1 January 14, 1993

The highest FY93 concentrations for 24-hour SO_2, 1-hour CO, and 1-hour NO_x were recorded on January 14, 1993. The maximum 24-hour SO_2 concentration was 0.015 ppm, and the maximum 1-hour CO concentration was 7.65 ppm at 2400 MST. A FY93 maximum for 8-hour CO of 4.32 ppm was recorded at 0300 MST on January 15, 1993 which included the hourly CO values from 2000 MST on January 14 through 0300 MST on January 15. Table 5.7-4 lists the air quality and meteorological data for January 14 and the first three hours of January 15.

Winds at RMA were light and blew predominantly from the south and southwest during the period as shown in the wind rose (Figure 5.7-4). Pasquill stabilities and 10m-2m temperature differences indicate that a temperature inversion was present during the morning hours of January 14, weakened during the daylight hours of the 14th, and then re-formed very strongly during the hours that the maximum 8-hour CO was recorded.

Figures 5.7-5 and 5.7-6 compare hourly CO and SO_2 recorded at RMA on January 14 with data from CDH sites and average values for the month at RMA. Although SO_2 and CO

Table 5.7-4 Air Quality and Meteorological Data for January 14-15, 1993

	Hour (MST)	Carbon Monoxide (ppm)	Sulfur Dioxide (ppm)	Nitrogen Oxides (ppm)	Wind Direction	Wind Speed (mph)	Temp. (°F)	Relative Humidity (%)	10m-2m Temp. Difference (°F)	Pasquill Stability Class
1/14	100	1.44	0.012	0.095	180.5	3.3	15.7	83.1	5.7	D
	200	1.59	0.010	0.107	106.7	3.5	15.2	78.3	4.9	E
	300	2.01	0.007	0.151	136.3	5.3	14.1	85.6	4.4	E
	400	1.66	0.012	0.133	131.8	4.4	14.9	84.4	4.2	F
	500	1.42	0.013	0.125	145.3	6.0	13.1	83.2	4.8	E
	600	1.73	0.012	0.149	230.5	2.8	14.0	84.0	4.2	F
	700	2.30	0.010	0.197	159.4	2.2	14.8	91.6	5.1	F
	800	2.86	0.010	0.236	180.1	4.5	14.1	91.2	4.6	E
	900	5.15	0.011	0.370	176.6	5.2	16.5	90.7	2.1	D
	1000	4.21	0.010	0.306	244.4	2.7	20.9	76.4	0.2	C
	1100	4.41	0.010	0.314	28.8	2.9	25.5	68.2	-0.3	B
	1200	4.97	0.016	0.380	2.9	4.1	27.2	61.1	-0.3	C
	1300	4.29	0.030	0.324	22.1	6.4	28.5	59.2	-0.1	D
	1400	3.11	0.023	0.222	13.9	5.3	29.0	57.1	-0.3	C
	1500	2.67	0.020	0.180	16.0	4.7	29.1	54.5	0.1	B
	1600	2.45	0.014	0.162	73.5	2.6	29.7	52.7	0.4	C
	1700	2.31	0.015	0.155	60.2	3.0	27.4	55.4	1.6	D
	1800	2.24	0.017	0.155	130.8	5.5	26.1	58.7	5.3	D
	1900	1.90	0.018	0.127	127.0	3.0	28.1	58.3	8.4	E
	2000	2.18	0.017	0.153	352.3	2.4	25.6	63.2	5.1	F
	2100	2.52	0.015	0.174	229.2	2.6	26.6	64.2	9.8	F
	2200	2.94	0.022	0.211	203.3	3.6	27.6	62.2	8.2	F
	2300	6.23	0.026	0.466	205.8	7.0	27.3	69.2	7.1	E
	2400	7.65	0.021	0.525	206.5	8.5	27.3	81.8	5.7	E
1/15	100	5.84	0.018	0.399	192.2	8.7	27.5	85.5	5.7	E
	200	4.88	0.010	0.333	172.3	7.9	27.7	75.2	6.2	E
	300	2.35	0.004	0.156	175.8	8.2	27.4	73.9	6.2	E

MST Mountain Standard Time
ppm parts per million
mph Miles per hour
°F Degrees Fahrenheit
% Percent
m meters

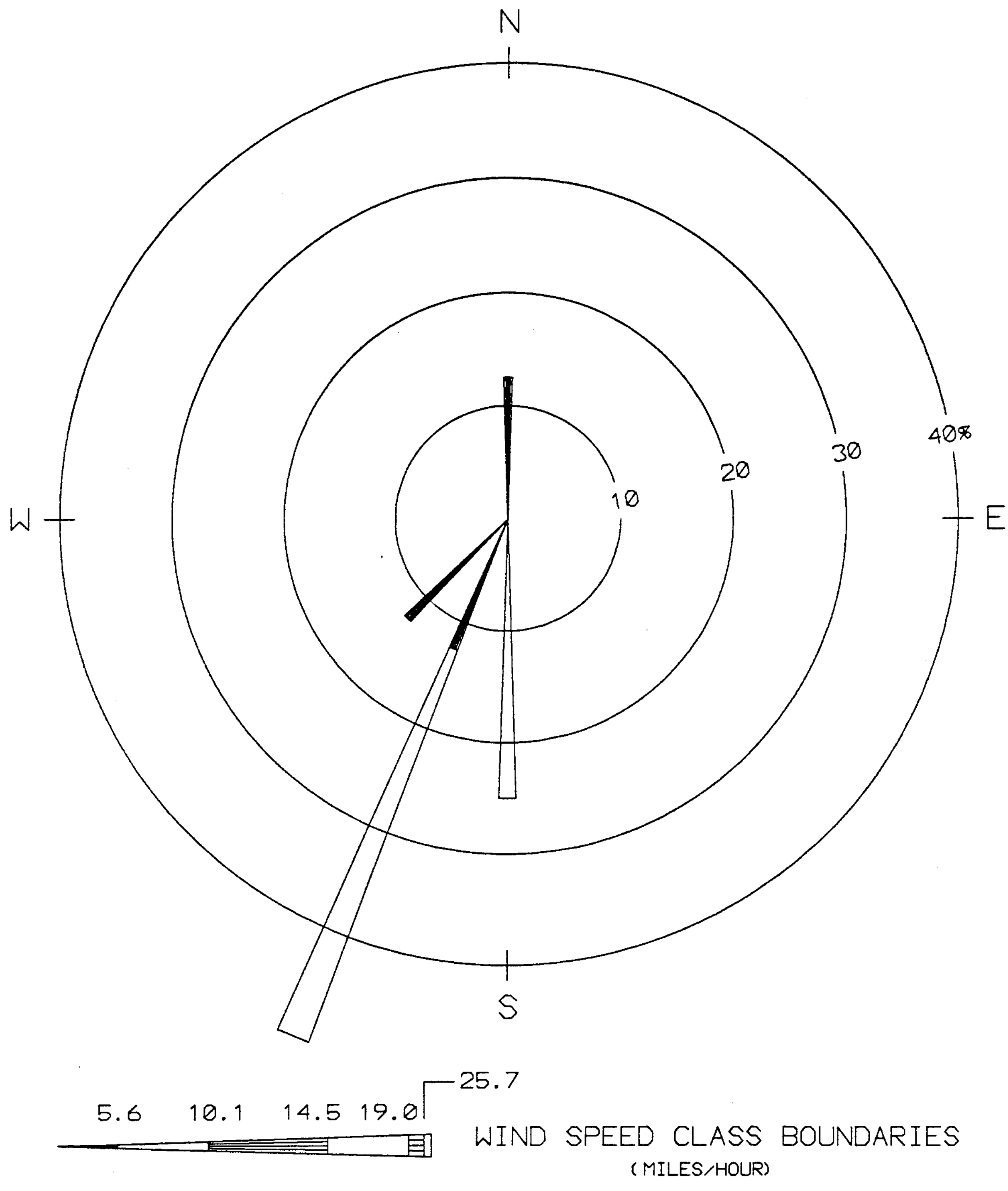

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Figure 5.7-4

RMA Wind Rose for January 14-15, 1993 2000-0300 MST

Rocky Mountain Arsenal
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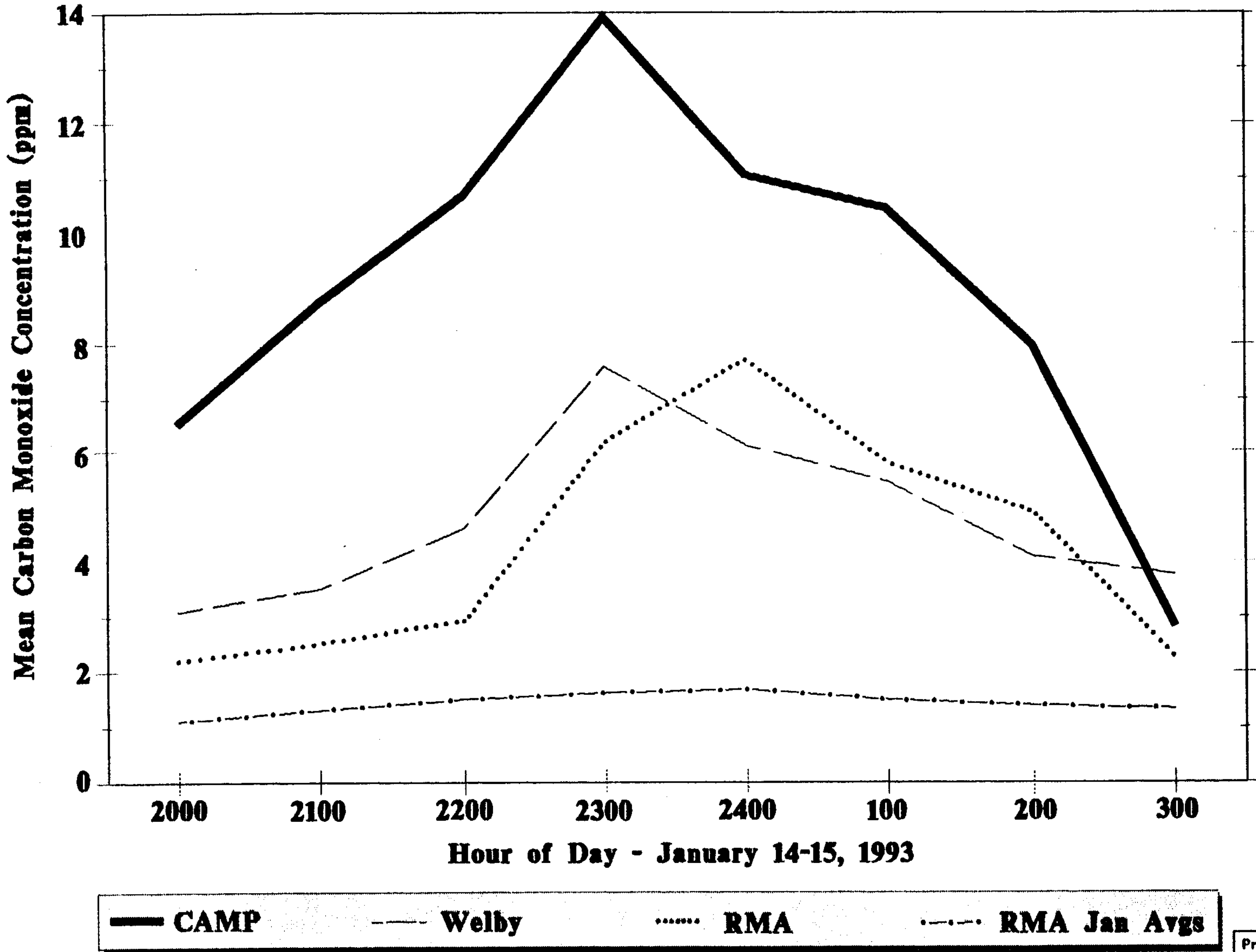

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Figure 5.7–5
Comparison of 1–Hour Carbon Monoxide Concentrations for RMA and CDH Sites January 14–15, 1993

Rocky Mountain Arsenal
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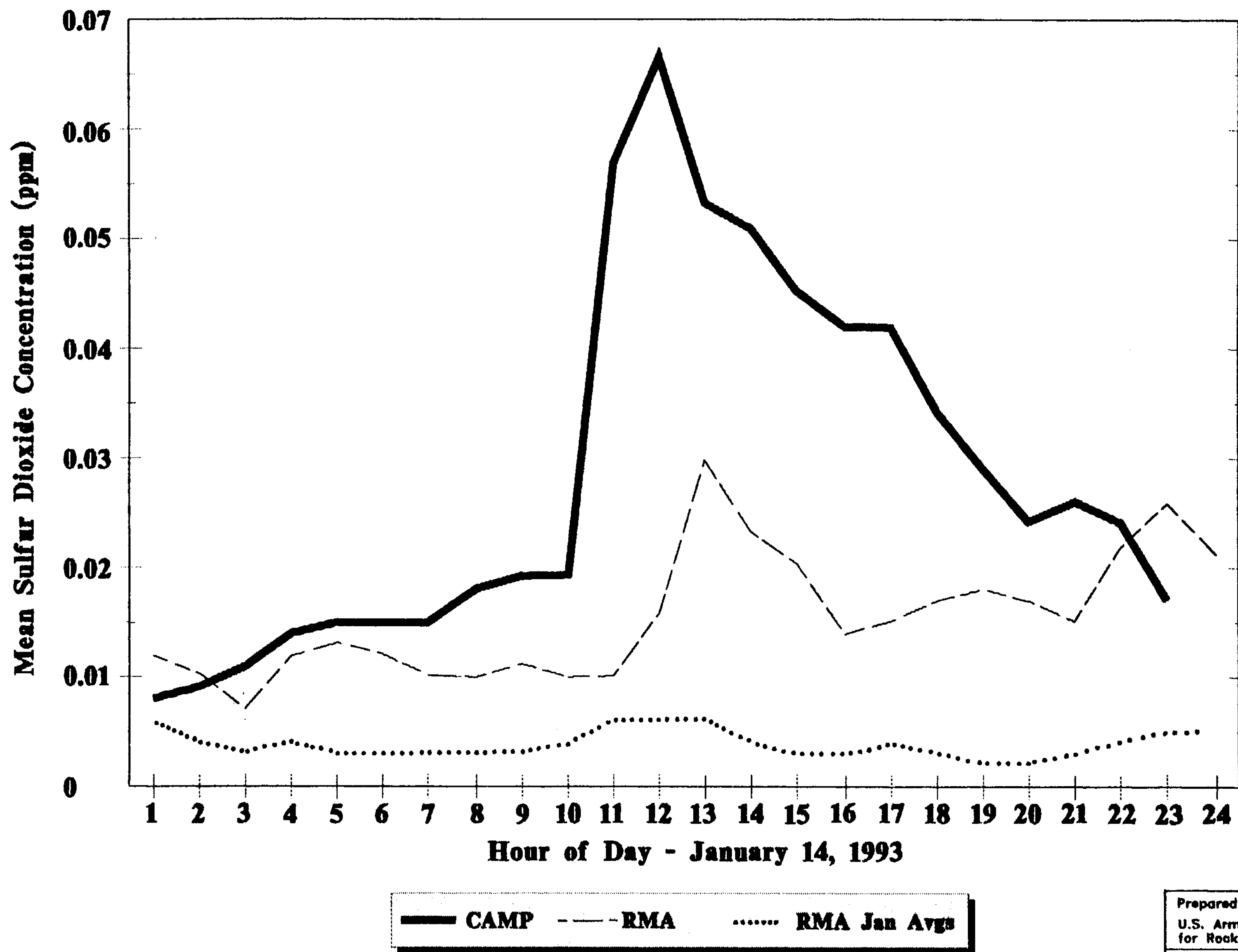

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U.S. Army Program Manager for Rocky Mountain Arsenal

Figure 5.7-6

Comparison of 1-Hour Sulfur Dioxide Concentration for RMA and CAMP Sites January 14-15, 1993

Rocky Mountain Arsenal
Prepared by: Ebasco Services Incorporated

concentrations were at their highest levels of the year at RMA, the figures show that they were still much lower than the CAMP site in downtown Denver. This indicates that stagnant air and light winds were trapping pollutants over a wide area and that the likely sources of the high levels of criteria pollutants at RMA were the surrounding mobile and industrial sources.

5.7.2 December 8, 1992

High levels of CO, SO_2, and NO_x were also recorded at RMA on December 8, 1992. An hourly CO value of 6.73 ppm at 1900 MST was the second highest 1-hour value for FY93. The 24-hour SO_2 concentration of 0.015 ppm was also the second highest value for FY93. Several 1-hour values for NO_x were the highest recorded for FY93 other than on January 14. Table 5.7-5 lists the air quality and meteorological data for December 8.

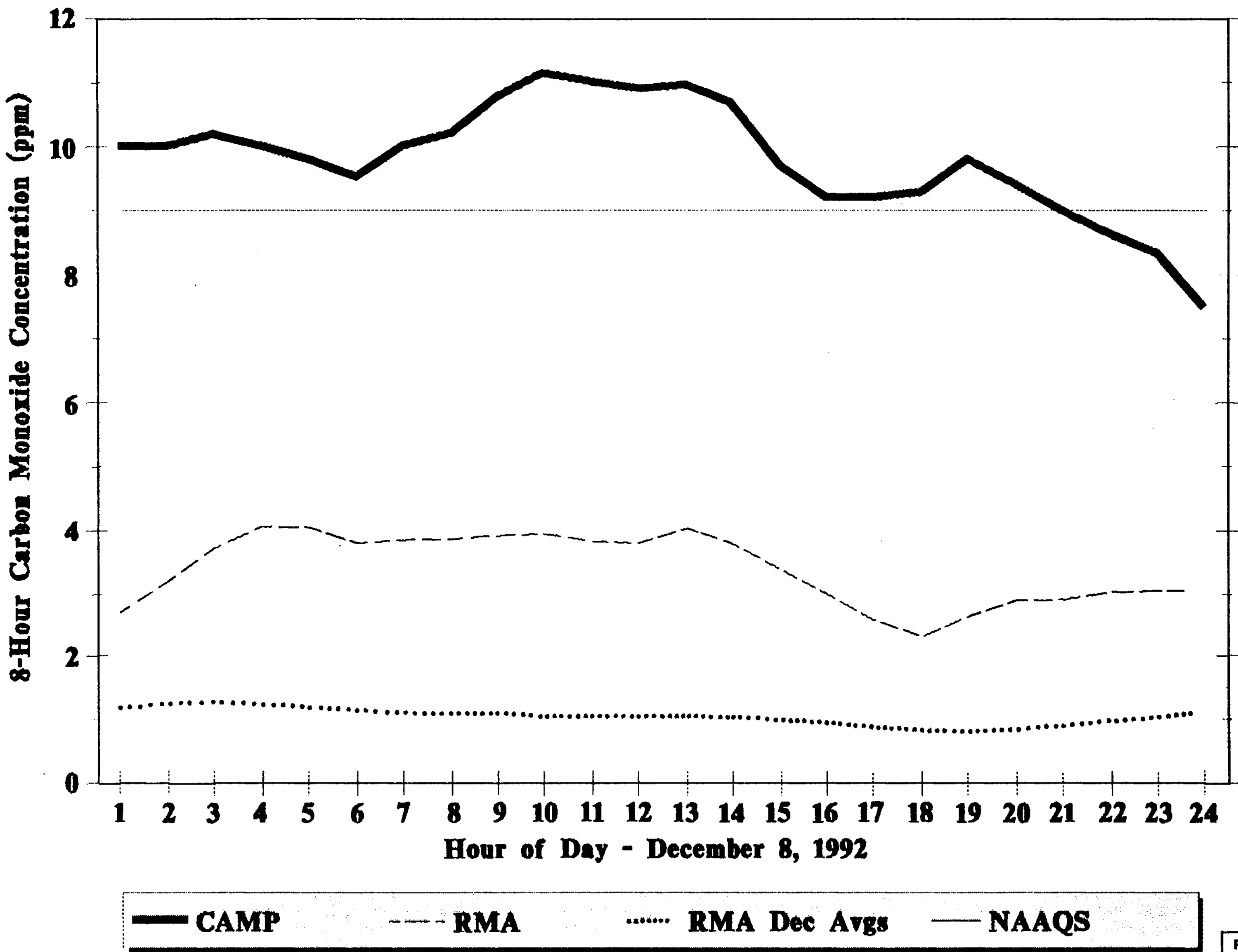
Winds on this day were predominantly from the south and a persistent temperature inversion was in place (see plot of the Stapleton Airport sounding in Section 4.2). The wind rose (also in Section 4.2) shows that the predominant wind direction was due south.

Figure 5.7-7 compares the 8-hour CO values recorded at RMA on December 8 to those recorded at the CAMP and Welby sites and average RMA concentrations for the month (Figure 5.7-8 compares the hourly SO_2 values recorded at the CAMP site to RMA). As the figures show, the CO and SO_2 levels at sites to the west and southwest of RMA were very high under the persistent inversion. The CAMP site recorded several violations of the 8-hour NAAQS for CO during the day. As with the episode of January 14, the source of the high levels of criteria pollutants at RMA on this day appears to be the mobile and industrial sources to the south and southwest.

Table 5.7-5 Air Quality and Meteorological Data for December 8, 1992

Hour (MST)	Carbon Monoxide (ppm)	Sulfur Dioxide (ppm)	Nitrogen Oxides (ppm)	Wind Direction	Wind Speed (mph)	Temp. (°F)	Relative Humidity (%)	10m-2m Temp. Difference (°F)	Pasquill Stability Class
100	4.65	0.017	0.338	179.8	2.5	25.3	67.4	9.0	F
200	4.95	0.018	0.407	315.5	3.5	23.9	74.8	5.7	F
300	5.26	0.021	0.423	313.6	3.2	23.9	77.4	6.4	F
400	3.97	0.019	0.314	17.0	4.4	22.9	73.2	5.2	F
500	1.75	0.009	0.126	320.6	2.6	23.8	67.4	3.4	F
600	2.48	0.011	0.184	246.4	4.0	23.7	69.8	6.4	F
700	4.03	0.019	0.359	185.1	6.8	23.7	67.6	6.4	E
800	3.85	0.036	0.298	182.7	7.0	25.2	53.2	6.9	D
900	4.74	0.037	0.303	175.1	6.7	26.8	48.9	4.8	D
1000	5.34	0.034	0.332	181.9	7.8	29.4	47.5	3.1	D
1100	4.39	0.022	0.275	169.7	5.6	34.4	43.7	1.7	C
1200	3.66	0.017	0.239	280.6	3.5	37.0	40.3	0.9	B
1300	3.58	0.014	0.259	8.7	8.7	31.2	48.6	0.2	C
1400	0.71	0.001	0.051	16.2	3.6	29.9	45.7	0.4	B
1500	0.55	0.001	0.042	177.8	3.5	32.8	36.9	0.5	A
1600	0.78	0.003	0.054	187.1	4.3	35.1	33.1	1.9	B
1700	1.57	0.010	0.132	197.4	6.5	36.9	25.5	5.7	C
1800	3.34	0.018	0.253	174.3	6.5	36.2	38.9	7.9	D
1900	6.73	0.019	0.442	167.4	5.7	34.3	50.9	8.4	E
2000	5.75	0.014	0.369	192.8	8.2	34.6	48.5	6.7	E
2100	3.44	0.009	0.237	187.5	6.9	32.7	46.5	6.5	D
2200	1.87	0.005	0.138	192.2	10.3	32.3	46.5	4.3	E
2300	0.85	0.001	0.058	195.2	13.3	33.8	46.2	3.4	D
2400	0.62	0.001	0.043	197.9	12.8	33.9	46.9	4.7	D

MST	Mountain Standard Time
ppm	parts per million
mph	Miles per hour
°F	Degree Fahrenheit
%	Percent
m	Meters



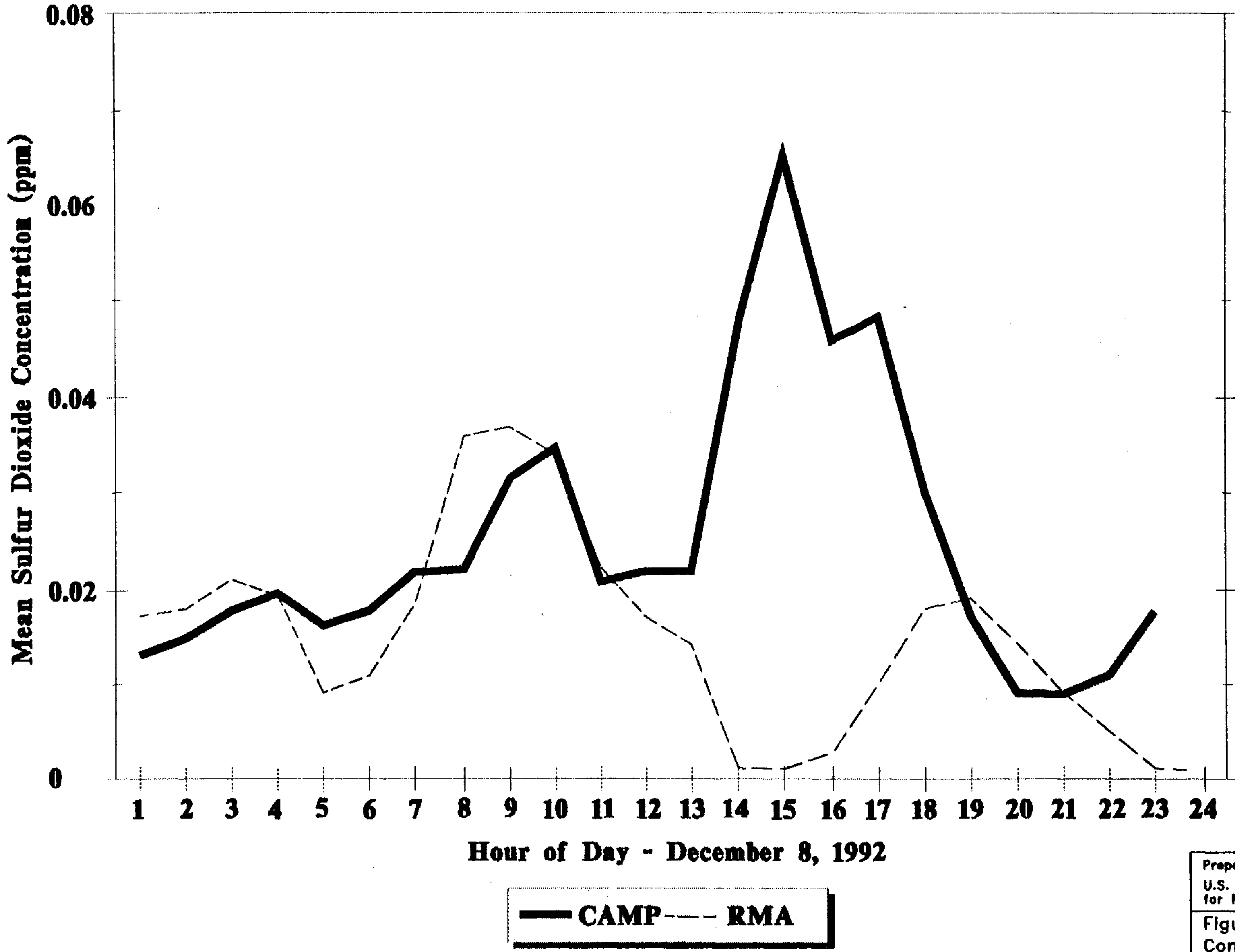
Prepared for:

U.S. Army Program Manager
for Rocky Mountain Arsenal

Figure 5.7-7

Comparison of 8-Hour Carbon Monoxide Concentration for RMA and CAMP Site December 8, 1992

Rocky Mountain Arsenal
Prepared by: Ebasco Services Incorporated



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for Rocky Mountain Arsenal

Figure 5.7-8
Comparison of 1-Hour Sulfur Dioxide Concentration for RMA and CAMP Site December 8, 1992

Rocky Mountain Arsenal
Prepared by: Ebasco Services Incorporated

6.0 METEOROLOGICAL MONITORING AND DISPERSION MODELING PROGRAMS

6.1 METEOROLOGICAL PROGRAM OVERVIEW

The meteorological program and station locations are described in Section 3.5. The locations of meteorological monitoring sites are shown in Figure 3.5-1. Complete listings of all data collected and used in this report are provided in Appendix J. Summaries of wind speed, wind direction, temperature, relative humidity, barometric pressure, solar radiation, precipitation, and atmospheric stability are provided in the following sections.

6.1.1 Program Objectives

The meteorological assessment has several objectives. The first is to identify the atmospheric conditions associated with typical contaminant levels or any abnormally high levels that might result from existing sources and remedial activity at RMA. Prevailing wind direction, wind speed, peak wind gusts, temperature, and precipitation all influence the release and spread of atmospheric emissions. The meteorological database has been established to identify typical relationships and to examine seasonal and diurnal patterns. For example, gusty winds will often result in higher levels of total suspended particles, inhalable particles of less than 10 micrometers, metals, and possibly semivolatile organic compounds. Certain pollutant emissions may vary with the seasons, which would be an important factor for remediation planning. Also, diurnal influences (such as the formation of a drainage wind pattern during evening and early morning inversion periods) may influence the levels or spatial distribution of certain pollutants. Knowledge of these patterns is useful in assessing the potential movement of contaminants during remedial activities.

The meteorological program also supports air quality model applications that are used in pollution dispersion evaluations and predictions. These analyses are employed for assessing impacts beyond the RMA boundary, and for predicting real-time pollution levels during remedial activities.

6.1.2 Data Recovery

Details of the recovery of FY93 meteorological data for each parameter of the composite database are provided in Table 6.1-1. Recoveries are based on the total number of hours of possible (8,760) data during FY93. All observations (hourly values) were considered invalid or missing if there were less than 45 minutes of valid recorded data for that parameter.

6.1.3 Databases

A single, representative composite database was developed from data collected at the RMA meteorological sites. Meteorological Station 4 (M4) was the primary source for wind speed, wind direction, sigma theta (standard deviation of the horizontal wind direction fluctuations), temperature, precipitation, and barometric pressure. The remaining parameters in the composite database were taken from other sites. Relative humidity and the 10-meter minus 2-meter temperature difference were taken from Meteorological Station 1 (M1), and solar radiation was taken from Meteorological Station 3 (M3). In the event that any of the data from M4 were invalid, data from the other sites were substituted. These substitutions amounted to less than 0.5 percent of the FY93 database. It should be noted that temperature difference measurements at M1 were for purposes of relative indications as opposed to precise measurements. The M1 temperature sensors at each level meet PSD specifications as independent indicators, but are not intended to meet PSD requirements for delta-temperature systems.

Separate databases were also maintained for each site and were used for site comparisons within the RMA boundary to note any areal differences (see FY92 data report for comparison between RMA meteorological stations [WCC, 1993]). All summaries shown in this report were taken from the FY93 composite database. All data have been thoroughly checked for quality. Long-term climatological means for Denver Stapleton International Airport (Section 2.2) were used for comparison. In some cases, FY93 CAQMMP data were compared to FY88-FY92 CMP/CAQMMP data.

Table 6.1-1 Summary of Rocky Mountain Arsenal Meteorological Monitoring Data Recovery for FY93

Parameter	Annual Recovery %
Wind Speed	100.0
Wind Direction	100.0
Sigma Theta	100.0
Temperature	100.0
Relative Humidity	99.9
Barometric Pressure	100.0
Solar Radiation	99.9
Precipitation	100.0
Maximum Gust	100.0
Temperature Difference (10m -2m)	99.9

m meters
% Percent

6.2 SUMMARY OF RESULTS

A summary of monthly and annual meteorological data for FY93 at RMA is provided in Table 6.2-1. All parameters summarized in this table are based on hourly averaged values with the exception of maximum gust, which is the maximum instantaneous wind speed for the period. Maximum speed is the maximum 1-hour average wind speed value for the period. The predominant wind direction indicates the sector (of 16 possible sectors) from which the wind is blowing most frequently during the reported period. Temperature difference is the difference in temperature between the 10-meter and 2-meter sensors located on the 10-meter tower.

6.2.1 Temperature

The RMA FY93 annual mean temperature of 47.8°F was below the long-term Denver average of 50.3°F. The monthly mean temperatures were cooler than average for all but 2 of the 12 months. The months of November through February showed the greatest deviation from normal as all were 4°F to 7°F cooler than average. Only the months of October and March were warmer than average. The maximum monthly average was 70.9°F in July, and the minimum monthly average was 25.4°F in January. The maximum temperature, 94.2°F, was recorded in July, and the minimum temperature, -8.7°F, was recorded in February.

6.2.2 Relative Humidity

The annual mean relative humidity for FY93 was above normal at 58.3 percent. The monthly average relative humidities followed the typical pattern, with higher values in the winter and spring due to lower temperatures and increased amounts of precipitation, and lower values in the summer and fall. The maximum monthly average humidity was 72 percent in February, and the minimum monthly average was 44 percent in October.

6.2.3 Barometric Pressure

The annual mean station barometric pressure for FY93 was 24.75 inches of mercury (in. Hg), which was above the long-term normals. The maximum monthly average was 24.84 in. Hg in August, and the minimum monthly average was 24.66 in. Hg in April.

Table 6.2-1 Summary of Rocky Mountain Arsenal Monthly Meteorological Conditions for FY93 (October 1, 1992 Through September 30, 1993)

		Temperature (°F)					Mean Meteorological Data			Precipitation (inches)		
	Month	Avg Max.	Avg Min.	Extreme Max.	Extreme Min.	Mean	Relative Humidity	Station Pressure (in. Hg)	Daily Solar Radiation (Ly/Hr)	Total	Max. 24-Hr.	# of days with measurable precipitation
1	Oct	66.0	41.2	82.5	23.0	53.1	43.6	24.82	0.23	0.18	0.10	3
2	Nov	43.4	25.5	66.6	9.9	33.7	64.4	24.75	0.14	0.30	0.18	3
3	Dec	36.2	15.5	52.8	-2.0	25.9	68.4	24.69	0.14	0.09	0.06	3
4	Jan	35.1	17.7	57.4	-2.2	25.4	72.2	24.72	0.15	0.02	0.02	1
5	Feb	37.1	20.0	56.7	-8.7	27.8	72.3	24.72	0.20	0.26	0.07	6
6	Mar	51.5	31.3	71.4	7.8	41.3	55.1	24.75	0.28	0.20	0.08	4
7	Apr	56.8	36.0	76.8	27.5	46.6	54.8	24.66	0.35	1.24	0.52	6
8	May	67.6	46.9	81.4	33.9	56.8	56.8	24.74	0.39	1.56	0.85	11
9	Jun	76.6	53.1	92.2	41.4	65.4	50.0	24.70	0.44	1.43	1.11	6
10	July	84.1	58.4	94.2	51.2	70.9	50.2	24.74	0.41	0.60	0.15	10
11	Aug	78.5	57.3	89.8	48.0	67.7	55.9	24.84	0.33	1.30	0.73	9
12	Sept	70.7	48.0	87.6	32.0	58.9	55.6	24.83	0.30	1.03	0.34	8
	Year	58.6	37.6	94.2	-8.7	47.8	58.3	24.75	0.28	8.21	1.11	70

°F Degrees Fahrenheit
in. Hg Inches of mercury
Ly/Hr Langleys per hour

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Table 6.2-1 Summary of Rocky Mountain Arsenal Monthly Meteorological Conditions for FY93 (October 1, 1992 through September 30, 1993)

		Wind Speed (mph)					Atmospheric Stability Category (% occurrence)					
	Month	Mean Speed	Maximum Speed	Maximum Gust	Predominant Wind Direction	Average Temp Diff	A	B	C	D	E	F
1	Oct	8.0	35.7	46.7	SSW	2.1	8.1	9.4	12.4	38.0	26.9	5.2
2	Nov	7.5	33.0	53.1	SSW	2.0	2.9	5.8	10.1	44.3	31.5	5.3
3	Dec	7.7	29.4	39.2	SSW	2.8	1.7	5.1	9.5	48.5	26.1	9.0
4	Jan	6.9	31.7	46.2	SSW	2.2	1.5	3.8	8.3	49.3	27.3	9.8
5	Feb	6.9	27.6	40.4	South	1.4	3.0	4.9	10.4	46.3	30.1	5.4
6	Mar	9.3	31.2	62.9	South	1.1	5.4	7.1	12.1	47.3	25.0	3.1
7	Apr	9.4	33.5	50.3	South	0.9	7.4	11.4	11.3	47.5	19.4	3.1
8	May	7.9	30.3	51.1	South	1.1	9.0	10.6	17.1	41.1	18.3	3.9
9	Jun	8.9	28.7	47.0	SSW	0.8	10.6	12.6	16.1	42.8	15.4	2.5
10	July	9.7	35.7	53.2	South	0.6	8.3	10.5	15.3	50.5	13.7	1.6
11	Aug	8.0	25.2	40.6	South	0.8	9.8	12.0	16.5	36.4	23.1	2.2
12	Sept	8.6	30.5	60.6	SSW	1.0	7.9	10.0	12.4	44.2	23.5	2.1
	Year	8.2	35.7	62.9	SSW	1.4	6.3	8.6	12.6	44.7	23.3	4.4

Legend:
- Maximum Speed — Maximum 1-hr average wind speed value for the month
- Maximum Gust — Maximum instantaneous wind speed for the month
- Temp Diff — Temperature difference (10-meter minus 2-meter) on the tower
- SSW — South-southwest

A = Extremely Unstable
B = Unstable
C = Slightly Unstable
D = Neutral
E = Stable
F = Extremely Stable

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6.2.4 Solar Radiation

The solar radiation statistics include evening values to show the increase in solar radiation in the spring and summer due to the length of the days. The annual mean solar radiation for FY93 was 0.28 langleys per hour (ly/hr). Values were higher in the summer and lower in the winter, as expected. The maximum monthly average was 0.44 ly/hr in June, and the minimum monthly average was 0.14 ly/hr in November and December.

6.2.5 Precipitation

Precipitation for FY93 totaled 8.21 inches at RMA, compared with the Denver climatological mean of 15.31 inches. Every month during FY93 was drier than long-term Denver averages. The heaviest monthly precipitation total (1.56 inches) was measured during May, which historically receives the heaviest precipitation. The driest month was January (0.02 inches).

6.2.6 Winds

Hourly mean wind speeds for FY93 averaged 8.2 mph compared to the Denver long-term mean value of 8.7 mph. This comparison is important because pollutant levels, especially those associated with dust particles (i.e., TSP, PM-10, metals, and SVOCs), are sometimes generated by high wind speeds. The data show that FY93 mean wind speeds were below average for November through May. The maximum monthly average was 9.7 mph in July, and the minimum monthly average was 6.9 mph in January and February. The maximum gust, 62.9 mph, was recorded in March. The predominant wind direction for RMA in FY93 was south-southwest; while in Denver, winds are predominantly from due south.

The 5-year (1988-1992) wind rose for Stapleton Airport and the RMA wind rose for FY93 are shown in Figures 2.2-1 and 3.2-1, respectively. The FY93 wind rose showed predominantly southerly and south-southwesterly flows as compared to the predominant flow at Stapleton Airport of south to north. The secondary maximum wind direction at RMA was north-northeasterly while the Stapleton secondary maximum was from the north.

6.2.7 Atmospheric Stability

Atmospheric stability is an important factor in the dispersion of air pollutants. Along with wind speed and wind direction, it is a key parameter in air quality dispersion models and reflects the potential for the atmosphere to disperse pollutants horizontally and vertically. Hourly stabilities for RMA are assigned one of six possible Pasquill stability categories (A through F) with "A" being the most unstable and "F" being the most stable. The hourly categories are determined by a combination of wind speed, sigma theta, and the time of day of the observations. Table 6.2-1 shows the percent occurrence for all atmospheric stability categories for the FY93 RMA composite data set. A joint frequency distribution for FY93 is provided in Appendix L.

Unstable categories A, B, and C indicate active dispersion and occur primarily during midday and afternoon periods, and most often in the warmer seasons. These categories were measured 6.3 percent, 8.6 percent, and 12.6 percent of the time, respectively, or a total of 27.5 percent of the time. Stable categories E and F, reflect poor dispersion and occur during morning hours and more often in the colder seasons. These stability categories were measured 23.4 percent and 4.4 percent of the time, respectively, or a total of 27.8 percent of the time. The remainder of the hours, 44.7 percent, were in Category D, which reflects neutral stability. Hours with high mean wind speeds are categorized as being neutral in stability, but as mentioned earlier, strong winds also have the potential to increase dust-associated particles emissions.

Another indicator of stability is the temperature difference between the 10-meter and 2-meter levels. Greater average temperature differences were recorded in the colder seasons (more stable), compared to smaller differences in the summer (more unstable or neutral).

The stability data for FY93 appear to be typical for the Denver area. The inversion conditions associated with poor dispersion categories E and F were less frequent during the spring and summer, and occurred primarily in the evening and early morning periods. During the winter, there were many inversion periods that lasted continuously for several days and intensified the

brown cloud over the Denver area. During spring and summer, the dispersion potential was more typically bimodal, with excellent dispersion during the day and poor dispersion at night.

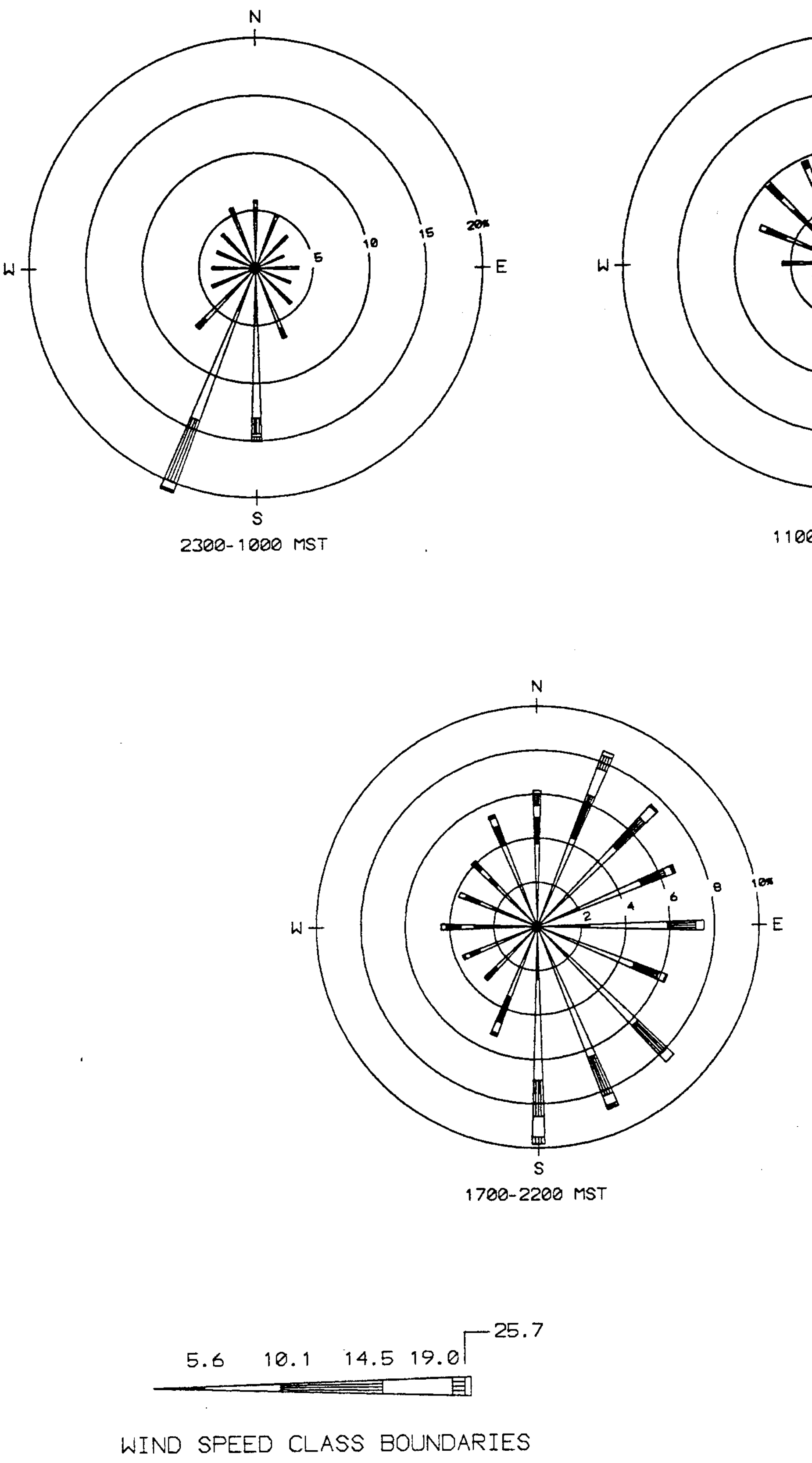
6.3 SEASONAL AND DIURNAL INFLUENCES

Dispersion characteristics are closely related to diurnal cycles in atmospheric stability and wind patterns. During the day, when dispersion conditions are good (categories A, B, and C), winds are highly variable and frequently gusty. At night, when the inversions set in and dispersion is poor (categories E and F), winds are generally light and follow a drainage pattern from the south-southwest to the north-northeast. This diurnal pattern is illustrated in Figure 6.3-1. The 2300-1000 MST wind rose shows the persistent, light winds from the south and south-southwest in the evening and morning hours, while the 1100-1600 MST wind directions are more variable in the northeast quadrant with stronger wind speeds. The 1700-2200 MST pattern is transitional from the afternoon pattern to the evening/morning pattern.

Figure 6.3-2 shows that the wind patterns in FY93 did not vary significantly from season to season. Historically, this has been typical of both RMA and Denver Stapleton Airport (see previous RMA annual reports for detailed comparisons between RMA and Stapleton seasonal and diurnal patterns). The distribution of stability categories at RMA does vary by season, however. For example, during FY93, unstable category A occurred 10.6 percent of the time in June but only 1.5 percent of the time in January, while stable category F occurred 9.8 percent of the time in January, but only 1.6 percent of the time in July.

6.4 SUMMARY AND CONCLUSIONS

Although mean weather patterns may vary from year to year, it appears that the FY93 meteorological data, with minor differences, were representative of long-term data and provide a useful instrument for assessing contamination impacts during this period and for future remedial progress evaluations. Table 6.4-1 provides a comparison of FY93 meteorological parameters with those of FY89 through FY92. The only differences of note were: the predominant wind direction was southerly in FY89, FY90, FY91, and FY92, and south-southwesterly in FY93; and the solar

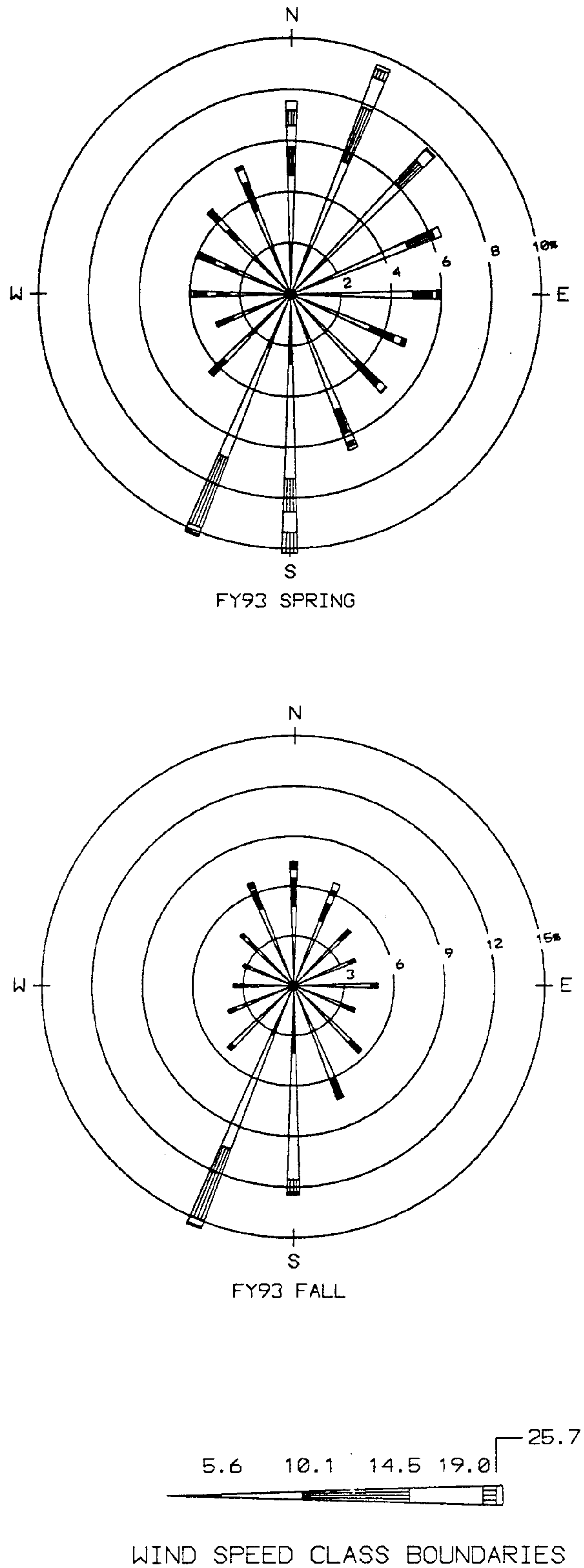


Prepared for:
U.S. Army Program Manager
for Rocky Mountain Arsenal

Figure 6.3-1

Diurnal Variation of RMA Winds for FY93

Rocky Mountain Arsenal
Prepared by: Ebasco Services Incorporated



Prepared for:
U.S. Army Program Manager
for Rocky Mountain Arsenal

Figure 6.3-2

Seasonal Variation of RMA Winds for FY93

Rocky Mountain Arsenal
Prepared by: Ebasco Services Incorporated

Table 6.4-1 FY89 - FY93 Meteorological Comparison

	FY93	FY92	FY91	FY90	FY89
Average Maximum Temperature (°F)	58.6	60.8	61.0	62.0	61.7
Average Minimum Temperature (°F)	37.6	39.7	39.1	39.9	38.6
Mean Temperature (°F)	47.8	50.0	49.5	50.6	49.9
Mean Relative Humidity (%)	58.3	54.3	49.2	52	49
Mean Total Daily Solar Radiation (Ly/Hr)	0.28	0.29	0.33	0.29	0.24
Total Precipitation (in)	8.21	13.09	16.16	11.56	12.41
Total Number of Days of Precipitation	70	82	68	67	77
Mean Wind Speed (mph)	8.2	8.1	8.7	8.6	8.5
Maximum Hourly Wind Speed (mph)	35.7	37.7	38.4	35.9	33.2
Maximum Wind Gust (mph)	62.9	69.4	62.0	52.8	72.5
Predominant Wind Direction	SSW	SOUTH	SOUTH	SOUTH	SOUTH

°F Degrees Fahrenheit
Ly/Hr Langleys per hour
in. inches
mph miles per hour
% Percent

radiation level of 0.24 ly/hr in FY89 was much lower than the values of 0.29 ly/hr in FY90 and FY92, 0.33 ly/hr in FY91, and 0.28 ly/hr in FY93. The solar radiometer was out of operation for a period during the summer of 1989, which may account for the annual differences for that parameter.

The data also suggest important guidelines for mitigation that may be appropriate during remedial activities. Emissions from daytime activities would contribute lesser impacts than evening and early morning activities because of the stronger dispersion conditions during the day. At night, inversions are prevalent and dispersion conditions are poor. Also, winds at night are channelled north and northeast of the remediation source. The distance from a remediation source to sensitive areas beyond RMA boundaries should also be taken into account.

In this section, typical impacts were inferred based on seasonal and diurnal meteorology. For real-time applications, or for short-term and long-term assessments, these influences must be incorporated into atmospheric dispersion models along with detailed source emission characteristics. Model approaches employed in the present report and recommended for future remedial progress evaluations are discussed in Section 6.5.1.

6.5 ATMOSPHERIC DISPERSION MODEL

6.5.1 Model Approaches

One of the objectives of the CAQMMP is to identify atmospheric conditions that may trigger high contamination levels and may require special precautions and mitigating actions. A related task is the development and/or application of air dispersion prediction techniques and models that use available site data and provide forecasts of potential contamination impacts. The Basin F program developed and applied such modeling techniques as an integral part of its program to provide for the health and safety of workers and the general public. The CMP/CAQMMP closely coordinated these operational activities and incorporated dispersion model results into previous reports as well as the present report. These techniques appear to be effective and are

recommended for future remedial and air quality assessment applications. Specific models used in remedial operations and in data assessments are discussed below.

The models employed were the EPA Industrial Source Complex (ISC) Model (EPA 1986a) and the PUFF Advection Model (INPUF) (EPA 1986b). These are standard and approved EPA models used for general purposes to predict air quality impacts. They are often used in environmental impact statements and air quality permit applications. For Basin F remedial activities, they were modified to support the cleanup operations, and in particular, to use real-time air quality and meteorological data.

Because precise measurements of source emissions could not be determined, a unique approach was devised to use X/Q values, in conjunction with measured ambient concentrations, to predict short-term (operational) and longer-term (assessment) impacts. The X/Q values, as noted in previous discussions relating to the CMP, CAQMMP, and Basin F monitoring results, do not indicate ambient concentrations, but rather, indicate relative strength or potential concentration levels, based on meteorological conditions and on an undetermined emission source strength. In the Basin F program, the X/Q values were calibrated with real-time monitoring data to predict ambient concentrations in support of the remedial operations. In Gaussian dispersion models, the ground-level concentrations of contaminants in a plume can be computed as follows:

$$\mathbf{X}=\frac{Q}{\pi\sigma_y\sigma_z u}\cdot\exp\left[-1/2\left[\frac{ESH}{\sigma_z}\right]^2\right]$$

Where

X	=	predicted ground-level concentration (g/m^3)
Q	=	source emissions (g/s)
σ_y	=	horizontal dispersion coefficient (function of distance from source) (m)
σ_z	=	vertical dispersion coefficient (function of distance from source) (m)
u	=	mean wind speed at plume level (m/s)
ESH	=	effective stack height, or plume height level assumed for Basin F application (m)

When the source emission term is not determined, the equation can be written as follows:

$$X/Q = \frac{1}{\pi \sigma_y \sigma_z u} \cdot \exp\left[-1/2\left[\frac{ESH}{\sigma_z}\right]^2\right]$$

For the recent assessment applications, assuming that Q is constant or near constant at any given time, the relationship between an observed (monitored) concentration (at a specific grid location where X/Q was calculated) and at another unmonitored location (where X/Q was also determined) was the ratio between the two values. This was a very simple approach, but was highly effective in determining the spread of a dispersion plume beyond and between the monitoring networks. This technique will allow for the prediction of future concentrations during ongoing operations, assuming that emissions do not significantly change during a particular operation. As remedial progress continues and emissions are eventually reduced, observed concentrations for a specified X/Q should also be reduced. Thus, the model has the potential to evaluate remedial progress under comparable meteorological and air dispersion conditions.

The PUFF Advection Model was used primarily for short-term predictions at Basin F in conjunction with real-time operations. Air monitoring was conducted using an OVM, an OVA, an ammonia monitor, and dust monitors at various remedial activity areas and along the Exclusion Zone perimeter. Perimeter readings were taken at four fixed locations and also downstream from Basin F, where maximum concentrations were anticipated (based on the prevailing wind). Concurrent with each monitoring reading, the PUFF Advection Model was run to determine the trajectory of the contamination plume. The X/Q values of the model were then immediately matched with actual monitored data to determine the potential distribution of the plume trajectory and the likelihood of Level B exceedances outside the protected areas. A maximum limit of 1 ppm was established for expansion of the Exclusion Zone and/or evacuation of personnel without protective clothing and equipment. The PUFF Advection Model was not employed during FY93.

Both the PUFF Advection Model and the ISC Model have the capability to provide longer-term X/Q dispersion assessments. The PUFF Advection Model operates on 15-minute trajectories. Although it takes much longer to run, the PUFF Advection Model can be used to assess longer-term episodes if more refined or sensitive analyses are required. The ISC Model was primarily employed for assessments at least 24-hours in length.

The results of the CMP, CAQMMP, and Basin F monitoring programs, discussed in Section 4, were compared with dispersion analyses obtained from the ISC Model. As noted, their evaluations provided highly useful information for associating dispersion patterns and meteorological conditions with observed and potential air contamination levels. When a distinct source was evident, such as Basin F, Basin A, or the South Plants, the model identified the spread of the dispersion plume downstream from the source. The concurrent monitored data then provided a mechanism for calibrating and projecting ambient concentrations throughout RMA and beyond its boundaries. The model identified worst-case meteorological conditions and seasonal and diurnal effects, thus providing a basis for mitigation actions if appropriate. For future assessments, it provides a basis for evaluating remedial progress by ensuring that monitoring results are compared to similar worst-case meteorological and seasonal conditions.

The strengths and weaknesses of model applications is evident from the data and comparisons given in previous RMA assessments. The impacts from known RMA sources or remedial activities have been identified. The relative strength of these impacts, taking into account distance from the source, have also been quantitatively determined. There is a considerable scattering of actual concentration values at specific site locations, which can be attributed to many factors beyond the simplified model's present capabilities. These include variations in source emissions and remedial production activity, both of which obviously result in variations in source concentration levels downwind from the source; the existence of other potential area and local sources, which present a noise factor in the database; short-term meteorological influences that are not integrated into the hourly ISC database (this suggests the special advantage

in using the short-term PUFF trajectories); and the general complexity of the dispersion process that is not entirely identified in the model.

In summary, the PUFF Advection and ISC Models, using the X/Q calibration approach, were and will continue to be workable vehicles for projecting contamination levels during remedial activities and for assessing remedial progress. It is not the purpose of the CAQMMP to perform extensive research investigations to improve model validation and applications. Nevertheless, several practical follow-up approaches may be applied in future CAQMMP evaluations that would not only improve the models but would also provide considerable insight into the general assessment of RMA contamination levels during subsequent remedial activities. These additional approaches are discussed below.

6.5.2 Additional Model Approaches and Analyses

6.5.2.1 Source Emissions Characterization

The standard dispersion model predicts ambient concentrations based upon meteorological factors and a known, or estimated, emission source. The Basin F real-time application, and the CMP/CAQMMP have, to a certain extent, effectively bypassed the emissions term and substituted a mechanism (X/Q values) for providing contamination levels based upon concurrent monitoring data. More precise data on emission releases at potential RMA and off-site contamination sources will add an additional dimension to the modeling and prediction capabilities. Data indicating the combination of emission levels, meteorological factors, and resultant ambient concentrations will also allow for further refinements of the model. For subsequent cleanup activities at RMA requiring air quality impact assessments, precise emissions data and characterizations, to the extent possible, will enhance prediction capabilities.

6.5.2.2 Remedial Activity Production Data

It is evident from the Basin F monitoring results during remedial operations, and from the Remedial Investigation Program results obtained prior to remedial operations, that the cleanup activities resulted in increases in some of the monitored pollutants, in particular: TSP, pesticides,

organic compounds, and some metals. It may be assumed that these increases were a direct consequence of and proportional to the extent of remedial efforts on a day-to-day basis. Various information pertaining to the status and intensity of cleanup operations (including the tons of soil and sludge removed and hauled each day, the type and number of vehicles and equipment employed, the type and number of storage areas and uncovered waste pile areas, the number of gallons of liquid transported, and any other emission-producing factors related to operations) would be especially useful in assessing relative emissions potential and in refining model prediction capabilities. These data were available, to a limited extent, during the Basin F operations, but not necessarily on a real-time basis; this made it difficult to interpret the cause of higher contamination events and the extent of mitigation efforts that were needed. It should be noted that many industrial real-time air quality prediction systems are directly related to production factors, and this approach would have equally valid application for waste cleanup operations.

6.5.3 Local and Regional Emissions Inventory

One of the difficulties in analyzing the CAQMMP and Basin F data was that there were obviously other off-site, local, and regional air emissions sources in the RMA vicinity that contributed to air pollution levels measured at RMA monitoring sites. As noted in the data evaluations, metropolitan Denver was a source of TSP, PM-10, some metals, gaseous criteria pollutants, and undoubtedly, certain organics. Also, various industrial sources and farming areas in north Denver, Commerce City, and Adams County may have contributed to organics and other potential contaminants. Unless these sources are properly identified, they can present an unknown factor in the dispersion model prediction evaluations of potential RMA contamination and remedial impacts. Therefore, a complete inventory of local off-site sources is needed for the interpretation of baseline data and remedial progress at RMA. Work has begun on this effort, and an inventory of known sources is included in various sections of this report. These data contribute to the overall analyses. Additional work is also required in identifying the contributions and impacts of metropolitan mobile sources on RMA monitoring results. Again, quantification of such influences would enhance model evaluations and prediction capabilities.

Much of this information is available in the CDH files, the EPA's Air Toxics Study for Denver, and other reports, including the Citizens Report on Toxic Pollution in Colorado (see Section 4.0).

6.5.4 Empirical/Statistical Adjustments

A final approach for model improvement is to apply empirical techniques and pertinent, or unique, physical relationships to improve model capabilities. For example, it is generally agreed that organics are released into the atmosphere at warmer temperatures and also under certain favorable air pressure conditions; and TSP, metals, and PM-10 are generally higher after certain threshold wind gust levels are achieved. Also, very localized, topographic, site-specific characteristics, which are not considered in the dispersion model, may be evident in the spread of potential air contaminants over the area. The database now being collected provides a mechanism for establishing some of these influences; some have already been identified in the present and previous reports. It is anticipated that this effort will continue and, if possible, validated relationships will be incorporated into model applications.

7.0 QUALITY ASSURANCE PROGRAM

7.1 OVERVIEW

The CAQMMP Quality Assurance Program (QAP) for Air Monitoring was designed to ensure that the data generated met the requirements of the project and needs of the data user. The QAP also ensures that the accuracy and precision of collected data are measurable and acceptable. The majority of monitoring and analytical techniques used were certified by PMRMA; non-certified methods had EPA approval. Each method has its own prescribed quality control and quality assurance procedures which are in accordance with the Chemical Quality Assurance Plan (PMRMA 1989). The guidelines for developing monitoring methods and procedures are described in the following documents:

- "Draft CAQMMP Standard Operating Procedures" (EBASCO 1992b)
- "Draft Quality Assurance Project Plan" (EBASCO 1992c)
- "PMRMA Certified Analytical Methods" (PMRMA 1990)
- "Ambient Monitoring Guidelines for Prevention of Significant Deterioration," EPA-450/4-87-007 (EPA 1987)
- "Ambient Air Quality Monitoring, Data Reporting, and Surveillance Provisions," 40 Code of Federal Regulations, Parts 51, 52, 53, and 58 (CFR 1987a)
- "Quality Assurance Handbook for Air Pollution Measurement Systems," Volumes I, II, and IV, EPA-600/9-76-005, EPA-600/4-77-027a, and EPA-600/4-82-060 (EPA 1984b, 1985, 1983)
- "Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air," EPA-600/4-84-041 and updates (EPA 1984a)
- "Chemical Quality Assurance Plan," Version 1.0, July, 1989 (PMRMA 1989)

The following discussion on the definition of quality assurance is taken from the Quality Assurance Handbook for Air Pollution Measurement Systems, Volume I.

Quality assurance and quality control have been defined and interpreted in many ways. The more authoritative usages differentiate between the two terms by stating that quality control is the "system of activities to provide a quality product," while quality assurance or quality assessment is the "system of activities to provide assurance that the quality control system is adequate and effective." In other words, quality assurance is the verification of quality control.

Under PMRMA definitions, quality assurance is the total integrated program for assuring and documenting the reliability of monitoring and measurement data and for integrating quality planning, quality assessment, and quality improvement efforts to meet user requirements. Integrated into the QAP is quality control (QC), which is the routine application of procedures for obtaining prescribed performance standards in the monitoring and measurement process. Examples of QC activities are field and trip blanks, laboratory spikes, and duplicates.

For the purpose of the CAQMMP, quality control using project guidelines were those procedures that were routinely followed during the normal operation of the monitoring system. These included periodic field "spikes" and field blank sample analysis, collocated sample analysis, calibration of field and laboratory equipment, preventive maintenance, site inspection, and routine data screening and validation checks. Quality assurance (or quality assessment) were those procedures performed on a routine but less frequent basis to validate the data generation process. These assurance procedures were performed by a person not involved with the routine project activities. Quality assurance procedures included system and performance audits, standard intercomparisons, cross-checking of reported data values against original raw data records and data from other similar locations, and periodic evaluation of internal quality control data. The objective of the quality control and quality assurance procedures was to produce data that met RMA requirements measured in terms of precision, accuracy, representativeness, comparability, and completeness.

7.2 LABORATORY QUALITY ASSURANCE/QUALITY CONTROL PROGRAM

The laboratory quality assurance and quality control program was extremely rigorous and was based on PMRMA certification procedures. These procedures ensured the accuracy and integrity of the collected database through the analysis of two spiking levels and a control chart process of the resulting recoveries. The certification program consisted of the satisfactory completion of other precertification and certification procedures of the analytical methodologies, prior to sample analysis. In addition, prescribed routine quality control and quality assurance procedures were followed during the sampling program to ensure that each of the sampling methods maintained performance comparable to the level demonstrated during certification. The laboratory certification procedures consisted of determining several key parameters. Extraction or desorption efficiencies were determined by spiking the sample media with known amounts of the target analytes and performing the analyses along the analytical guidelines. A percent recovery for each of the compounds was determined from multiple spiking tests. Accuracy adjustments were determined from the mean of the percent recoveries at certification. One and two standard deviations from the mean of the recovery data were used to validate the subsequent data giving a 95 percent confidence level to the data. A range of concentrations was used to test the linearity of the laboratory instrument response and to certify an analytical range for each target analyte, with values denoted as the upper and lower certified reporting limits.

Reporting ranges were determined at the time of certification. Values found below this range were reported as "less than" the lower reporting limit. Values found above this range were reported as "greater-than" (GT), and were then estimated. These values are considered qualitative, and are used as a "best guess" of concentration ranges. Upper limits did not apply to TSP and PM-10 measurements. For SVOC, OCP and metals analysis, extract solutions were diluted (if possible) for reanalysis if the initial readings were above the certified range and holding times for the extracts had not yet expired.

The VOC laboratory analysis technique differed significantly from other techniques because there was no possibility of diluting or reanalyzing samples. The VOC Tenax and Tenax/charcoal

adsorption tubes were placed individually into a heating block connected to the inlet of the analytical instrument. This block, or thermal desorber, was quickly heated to desorb all the volatile compounds from the sorbent material. A small gas flow was passed through the tube simultaneously, which allowed these compounds to be quickly injected into the analytical instrument through a heated stainless-steel interface. Therefore, this method was a "one shot" technique, and if the sample concentration was outside certified limits, there was no way to dilute and reanalyze the sample. In the FY93 program, there were instances where a sample contained an amount above the certified range for some compounds. An assessment of the concentration was made by interpolating the concentration curve above the certified range. The results in these cases produced the best estimate of the observed concentrations. Although such GT values are not certified values, they provide essential information on the magnitude of the detected compound. The GT value supplied by the laboratory produces a partial representation of what was collected on the sample tube. Since the volatile method allows only one analysis per tube, the estimated greater than values are utilized. The estimated GT values began to appear in the Installation Restoration Data Management Information System (IRDMIS) database in August FY93. All GT values for FY93 are available in the laboratory packages and EBASCO database. For the FY93 program, additional GT results from ESE/Denver laboratory were obtained from microfilmed data packets maintained by RMA. The software employed by ESE/Denver to produce the estimated value generated the concentrations automatically. No manual integration or calculation was used.

In addition to the analyte measurements, laboratory accuracies, certified ranges, and extraction efficiencies were directly incorporated into the database processing system that was used to report air quality data. This system is the IRDMIS. In IRDMIS, the raw laboratory results are sent to EBASCO, the data are checked for errors, adjusted for sample volumes, and sent to DP Associates and held in the QC holding database. Once the Army has accepted data as having met the QA criteria, data are located into the official database. Data outside of certified ranges and rejected under the QA criteria are placed in a rejected data file for informational use only.

The resulting product is a high-quality analytical database that is available for assessment of RMA air quality.

7.3 FIELD QUALITY ASSURANCE/QUALITY CONTROL PROGRAM

7.3.1 Overview

During FY93 a comprehensive field QA/QC program was employed to ensure the collection of valid air quality and meteorological data. A Quality Assurance Project Plan was developed and implemented by an independent QA/QC group for the CAQMMP. All field staff received training in these as well as the program's SOPs. These SOPs clearly document the steps necessary to perform all field activities and serve as a resource for standardized data and calibration forms. Copies of all completed data forms were maintained in the field site files while the originals were filed by the project data management coordinator in the EBASCO Lakewood, Colorado office. All data forms were routinely reviewed and updated by the field supervisor under the guidance of the Field Technical Supervisor.

7.3.2 Ambient Air Sampling

The CAQMMP Technical plan and SOPs specify target flow rates and sample durations for each of the ambient air techniques as well air stripper and vent sampling techniques. These target values were used during the field sampling activities and were documented by periodic equipment calibrations as well as checks during each sampling event. Quality assurance limits were established using guidelines obtained from EPA QA handbooks for acceptable instrument performance. Corrective maintenance was performed whenever a flow rate or elapsed timer was outside of acceptable limits. All calibration and maintenance activities were documented in on-site logs by the field staff.

The high-volume samplers used to collect TSP, PM-10, and metals were electronically flow controlled to maintain the target flow rate. These samplers were calibrated quarterly or whenever additional maintenance was performed by using a certified orifice and following procedures prescribed in the appropriate reference method. These samplers were also equipped with Dickson

recorders that provided a 24-hour record of sample flow rate. The high volume samplers used for OCP/SVOC sampling were equipped with Magnehelic flow rate gauges. During quarterly calibrations, a linear relationship was established between the Magnehelic reading and the calibration orifice indicated flow rate.

Mercury, VOCs, and asbestos samples were collected using Volatile Organic Toxics Analyzer (VOTA) samplers or constant flow sampling pumps. These devices were adjusted to the target flow rate at sample installation by using a certified mass flow meter. Sampling equipment was also recalibrated whenever indicated flow rates exceeded target flow rates by greater than 7 percent.

7.3.2.1 VOC Quality Control Results

Collocated aerated samples and field and trip blank samples were submitted with each sample set to assess the method's precision and to identify potential sources of media contamination. Table 7.3-1 presents the FY93 VOC precision results. Average absolute percent difference for the collocated pairs range from 11.0 percent to 47.6 percent for the various target analytes. A variety of factors may account for this variability. These are discussed fully in Section 4.6.8. Table 7.3-2 summarizes the laboratory results for field and trip blanks samples. For 15 out of the 20 target analytes, all field and trip blank levels were less than the lower CRL. Trans-1,2-dichloroethene in a trip blank and benzene in a field blank registered 1 detection each at a level just above the lower CRL. 1,1,1-trichloroethene was detected on the field blank in 5 instances, most notably on 7/21/93 when 0.640 microgram was reported on the field blank. This amount is comparable to that measured on the field, aerated samples. Thus, 1,1,1-Trichloroethene results for this day should be viewed as suspect. Methylene chloride and toluene appear on both field and trip blank samples with some frequency at low to moderate levels. In most cases, the amount detected on the field and/or trip blank sample is small (i.e., < 10 percent) relative to the mass collected on the aerated samples. Nevertheless, data from the affected sample sets should be used with some caution. A complete listing of all field and trip blank results is provided in Appendix K.

Table 7.3-1 Summary of FY93 Volatile Organic Compound Precision Results

Analyte	Total # Samples	# Samples > Lower CRL	# Pairs > 30% Diff.	Avg. Abs. % Diff.	Avg. % Diff.	Std. Dev.	Min. Abs. % Diff.	Max. Abs. % Diff.	Lower 95% Conf. Limit	Upper 95% Conf. Limit
111TCE	56	54	13	22.3	4.9	32.1	0.3	117.1	-39.5	+49.4
112TCE	59	0	-	-	-	-	-	-	-	-
11DCLE	59	0	-	-	-	-	-	-	-	-
12DCLE	59	2	0	11.0	-1.9	15.6	9.1	13.0	-23.6	+19.7
12DCE	59	0	-	-	-	-	-	-	-	-
BCHPD	59	6	2	26.6	-23.7	31.1	5.0	78.8	-66.8	19.4
C6H6	56	54	15	27.1	2.6	44.2	0.3	192.1	-58.6	63.9
CCL4	56	53	16	23.9	6.2	33.7	0	116.9	-40.5	52.9
CH2CL2	56	54	26	42.8	3.5	61.4	0	168.7	-81.6	88.6
CHCL3	57	53	16	33.6	-2.9	54.5	0	165.8	-78.4	72.7
CLC6H5	59	0	-	-	-	-	-	-	-	-
DBCP	59	1	-	-	-	-	-	-	-	-
DCPD	59	0	-	-	-	-	-	-	-	-
DMDS	59	0	-	-	-	-	-	-	-	-
ETC6H5	57	35	23	41.7	-0.7	50.2	0	109.4	-70.4	68.9
MEC6H5	56	54	30	47.4	-1.0	62.5	1.4	174.7	-87.6	85.6
MIBK	59	0	-	-	-	-	-	-	-	-
TCLEE	56	44	20	34.2	-4.0	44.5	0	112.0	-65.6	57.7
TRCLE	59	5	0	14.4	-5.5	17.6	3.5	22.9	-29.9	18.8
XYLENES	57	36	24	47.6	0.7	56.7	3.4	120.0	-77.9	79.3

111TCE - 1,1,1-Trichloroethane
112TCE - 1,1,2-Tricholorethane
11DCLE - 1,1-Dichloroethane
12DCLE - 1,2-Dichloroethane
12DCE - trans-1,2-Dichloroethene
BCHPD - Bicycloheptadiene
C6H6 - Benzene
CCL4 - Carbon Tetrachloride
CH2CL2 - Methylene Chloride
CHCL3 - Chloroform
CLC6H5 - Chlorobenzene
DBCP - Dibromochloropropane
DCPD - Dicyclopentadiene
DMDS - Dimethyldisulfide
ETC6H5 - Ethylbenzene
MEC6H5 - Toluene
MIBK - Methyl Isobutyl Ketone
TCLEE - Tetrachloroethene
TRCLE - Trichloroethene
XYLENES - Total Xylenes

CRL - Certified Reporting Limit
ABS. - Absolute
AVG. - Average
Dev. - Deviation
Diff. - Difference
Conf. - Confidence
Std. - Standard

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Table 7.3-2 Summary of FY93 Volatile Organic Compound Field and Trip Blank Results

Analyte	Sample Type	Total # Samples	Total # Detections	Average Weight (µg)	Maximum Weight (µg)
1,1,1-Trichloroethane	FBLK	73	5	<0.023	0.640
	TRIP	75	0	<0.023	<0.023
1,1,2-Trichloroethane	FBLK	73	0	<0.037	<0.037
	TRIP	75	0	<0.037	<0.037
1,1-Dichloroethane	FBLK	73	0	<0.012	<0.012
	TRIP	75	0	<0.012	<0.012
1,2-Dichloroethane	FBLK	73	0	<0.012	<0.012
	TRIP	75	0	<0.012	<0.012
trans-1,2-Dichloroethene	FBLK	73	0	<0.012	<0.012
	TRIP	75	1	<0.012	0.017
Bicycloheptadiene	FBLK	73	0	<0.012	<0.012
	TRIP	75	0	<0.012	<0.012
Benzene	FBLK	73	1	<0.016	0.021
	TRIP	75	0	<0.016	<0.016
Carbon Tetrachloride	FBLK	73	0	<0.018	<0.018
	TRIP	75	0	<0.018	<0.018
Methylene Chloride	FBLK	73	43	0.285	2.710
	TRIP	75	13	<0.097	0.799
Chloroform	FBLK	73	0	<0.012	<0.012
	TRIP	75	0	<0.012	<0.012
Chlorobenzene	FBLK	73	0	<0.013	<0.013
	TRIP	75	0	<0.013	<0.013
Dibromochloropropane	FBLK	73	0	<0.100	<0.100
	TRIP	75	0	<0.100	<0.100
Dicyclopentadiene	FBLK	73	0	<0.089	<0.089
	TRIP	75	0	<0.089	<0.089
Dimethyldisulfide	FBLK	73	0	<0.048	<0.048
	TRIP	75	0	<0.048	<0.048
Ethylbenzene	FBLK	73	0	<0.032	<0.032
	TRIP	75	0	<0.032	<0.032
Toluene	FBLK	73	17	0.020	0.280
	TRIP	75	7	<0.014	0.210
Methyl Isobutyl Ketone	FBLK	73	0	<0.160	<0.160
	TRIP	75	0	<0.160	<0.160
Tetrachloroethene	FBLK	73	0	<0.013	<0.013
	TRIP	75	0	<0.013	<0.013
Trichloroethene	FBLK	73	0	<0.013	<0.013
	TRIP	75	0	<0.013	<0.013
Xylenes	FBLK	73	0	<0.149	<0.149
	TRIP	75	0	<0.149	<0.149

< ### Indicates value less than lower certified reporting limit
µg Micrograms

7.3.2.2 OCP/SVOC Quality Control Results

Table 7.3-3 presents the FY93 OCP precision results. Average absolute percent differences for the collocated pairs range form 6.3 percent to 15.9 percent for the target analytes. These results indicate that the OCP results are generally reliable. A complete listing of all OCP and SVOC field blank samples is provided in Appendix K. There were no detections of the target OCP or SVOC compounds in any of the blank samples. This indicates that the OCP/SVOC contamination is not present at detectable levels in the media or gained through the shipping and handling process.

In an effort to quantify the recovery efficiency of the SVOC/OCP sampling/analytical methods, three field spiking events were performed during FY93. On 12/22/92 and 4/29/93, two spiked samples were taken concurrently with one control (unspiked) sample, and the third event took place on 8/3/93 and included two aerated spiked samples, one non-aerated sample, and one control sample. A solution spiked with all of the SVOC/OCP target compounds was prepared by the PMRMA laboratory and employed by the project field staff for the spiking events. Samples were spiked by applying the solution directly onto a felt filter at the beginning of the sample period. The felt filter was placed over the regular quartz filter in the sampling module. Twenty microliters of the spiking mixture was applied to each spiked sample taken during the three spiking events. The results of the three spiking events are listed in Table 7.3-4. The recoveries for the nonaerated spiked sample (event #3) exhibit acceptable concentrations for all SVOC/OCP spiking compounds. This indicates a loss of target compounds during the aeration process. Consequently, analytical results for aldrin, CPMS, DBCP, vapona, DIMP, dithiane, DMMP, isodrin, and oxathiane must be interpreted carefully in view of their low or zero recoveries. The recoveries for the other target analytes showed the methods are efficient at collecting and retaining these contaminants of concern.

Table 7.3-3 Summary of FY93 Organochlorine Pesticide Precision Results

Analyte	Total # Samples	# Samples w/i CRL	# Pairs > 30% Diff.	Avg. Abs. % Diff.	Avg. % Diff.	Std. Dev.	Min. Abs. % Diff.	Max. Abs. % Diff.	Lower 95% Conf. Limit	Upper 95% Conf. Limit
Aldrin	60	6	1	8.8	-8.8	17.8	0	44.4	-33.4	15.8
Chlordane	60	10	0	6.3	-6.3	6.1	0	15.4	-14.8	2.2
Dieldrin	60	38	2	7.2	-2.7	11.3	0	40.0	-18.4	13.0
Endrin	60	6	1	15.9	-3.1	22.3	0	40.0	-34.0	27.8
Isodrin	60	0	-	-	-	-	-	-	-	-
PPDDE	60	0	-	-	-	-	-	-	-	-
PPDDT	60	1	-	-	-	-	-	-	-	-

w/i - within
Diff. - Difference
Avg. - Average
Abs. - Absolute
Conf. - Confidence
Std. - Standard
Dev. - Deviation

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Table 7.3-4 Summary of Semivolatile Organic Compound/Organochlorine Pesticide Field Spike Percent Recoveries

	Event #1 12/22/92		Event #2 4/29/93		Event #3 8/3/93		
Target Analyte	Sample #1	Sample #2	Sample #1	Sample #2	Sample #1	Sample #2	Sample #3*
Aldrin	64.7	88	26	28	22	0	89
Atrazine	92.4	140	40	51	71	78	84
Chlordane	GT	GT	110	110	94	90	92
CPMS	0	0	0	0	0	0	115
CPMSO	107	154	106	116	49	50	104
CPMSO2	102	148	100	110	88	89	99
DBCP	0	0	0	0	0	0	123
Vapona	0	22	0	0	0	0	55
DIMP	0	0	0	0	0	0	121
Dithiane	0	0	0	0	0	0	88
Dieldrin	72	118	87	95	81	80	82
DMMP	0	0	0	0	0	0	87
Endrin	96	152	115	121	86	87	87
Isodrin	56	78	26	33	24	21	88
Malathion	147	220	107	122	114	112	114
Oxathiane	0	0	0	0	0	0	51
ppDDE	60	89	91	97	86	84	90
ppDDT	81	129	93	95	87	88	82
Parathion	91	128	113	131	93	94	99
Supona	92	137	108	124	98	95	99

* Spike sample was not aerated

GT Above certified reporting limit (no percent recovery calculated)

7.3.2.3 Metals, Arsenic, and Mercury Quality Control Results

The results of collocated sampling for metals, arsenic, and mercury are presented in Table 7.3-5. These precision calculations demonstrate that the sampling method for these elements yields generally stable results. Copper proves to be a notable exception, with an average absolute percent difference of 43.6 percent. It is important to consider this variability when analyzing the data for spatial or temporal trends. As Table 7.3-6 shows, there was only one detection of a target metal analyte on a field or trip blank sample during FY93. Copper was measured on one field blank sample (out of a possible 81) at a level just above the lower certified reporting limit (12.8 micrograms). All arsenic field and trip blank samples were non-detects. Mercury was measured on 3 of the 84 field blank samples submitted at levels comparable to those typically measured on the aerated tubes. On two of those sample days, April 10, 1953 and July 9, 1993, no mercury was detected on any of the aerated samples. On June 10, 1993, mercury was detected at site AQ3. This value appears suspect as there was a greater mass of mercury measured on the field blank sample for this day. All field and trip blank data are presented in Appendix K.

7.3.2.4 TSP and PM-10 Quality Control Results

As discussed in Section 4.2, the laboratory experienced many problems in its gravimetric analysis of TSP and PM-10 filters during FY93. Quality control samples played a key role in identifying these problems and determining the effectiveness of corrective actions. The majority of these problems occurred during the period of October 1992 though January 1993. During the entire fiscal year sampling program, there were 13 field blank and 2 trip blank samples that showed appreciable weight gains or losses (> 5.0 milligrams net gain or loss). In addition, the laboratory reported negative net weights (i.e., < 0 milligrams) for 10 aerated TSP and 14 PM-10 samples. Furthermore, there were 69 pairs of samples at the same site where the reported PM-10 concentration was greater than the corresponding TSP value. All these data have been flagged in the data listings. Precision calculations were performed on the remaining valid collocated data sets and these results are documented in Table 7.3-7. All field and trip blank data are reported in Appendix K.

Table 7.3-5 Summary of Metals, Arsenic, and Mercury Precision Results

Analytes	Total # of Samples	# Samples within CRL	# Pairs > 30%	Average Absolute % Difference	Average % Difference	Standard Deviation	Minimum Absolute % Difference	Maximum Absolute % Difference	Lower 95% Confidence Limit	Upper 95% Confidence Limit
Cadmium	66	1	0	6.7	6.7	--	6.7	6.7	--	--
Chromium	66	0	--	--	--	--	--	--	--	--
Copper	66	66	38	43.6	-12.7	51.5	0.3	114.3	-84.1	58.7
Lead	66	3	0	9.5	9.5	5.2	5.5	15.3	2.3	16.6
Zinc	66	57	0	7.2	2.9	9.4	0.1	26.2	-10.1	16.0
Arsenic	66	4	0	11.4	11.4	9.4	0	20	-1.6	24.4
Mercury	67	0	--	--	--	--	--	--	--	--

CRL Certified Reporting Limits
% Percent
> Greater than
-- Not applicable

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Table 7.3-6 Summary of FY93 Metals, Arsenic, and Mercury Field and Trip Blank Results

Analyte	Sample Type	Total # Samples	Total # Detections	Average Weight (µg)	Maximum Weight (µg)
Cadmium	FBLK	81	0	<4.00000	<4.00000
	TRIP	18	0	<4.00000	<4.00000
Chromium	FBLK	81	0	<20.0000	<20.0000
	TRIP	18	0	<20.0000	<20.0000
Copper	FBLK	81	1	<10.0000	12.80000
	TRIP	18	0	<10.0000	<10.0000
Lead	FBLK	81	0	<40.0000	<40.0000
	TRIP	18	0	<40.0000	<40.0000
Zinc	FBLK	81	0	<20.0000	<20.0000
	TRIP	18	0	<20.0000	<20.0000
Arsenic	FBLK	81	0	<1.4100	<1.4100
	TRIP	18	0	<1.4100	<1.4100
Mercury	FBLK	84	3	< 0.1000	0.2180
	TRIP	0	0	NA	NA

< ##### Indicates result less than the lower certified reporting limit
µg micrograms
NA Not applicable

Table 7.3-7 Summary of TSP and PM-10 Precision Results

Analyte	Total # Samples	# Samples Valid	# Pairs > 15% Diff.	Avg. Abs. % Diff.	Avg. % Diff.	Std. Dev.	Min. Abs. % Diff.	Max. Abs. % Diff.	Lower 95% Conf. Limit	Upper 95% Conf. Limit
TSP	69	42	2	6	1	9	0	33	-12	+13
PM-10	60	35	9	11	0	21	0	86	-29	+28

Diff.	- Difference	Std. Dev.	- Standard Deviation
Avg.	- Average	Conf.	- Confidence
Abs.	- Absolute	>	- Greater than
%	- Percent		

7.3.3 Continuous Gaseous Monitoring Quality Control Results

Manual zero, span, and precision checks were performed biweekly at the continuous air quality monitoring site on all parameters. Tables 7.3-8 to 7.3-11 and Figures 7.3-1 to 7.3-4 present the results of these checks. The carbon monoxide, sulfur dioxide, ozone, and oxides of nitrogen results were generally stable with average absolute percent difference of 5.0 percent, 3.7 percent, 1.7 percent, and 5.8 percent, respectively. The NO_x analyzer underwent corrective maintenance in several instances during FY93 when daily and manual zero, span, or precision checks indicated out of tolerance conditions.

7.3.4 Audit Results

The CAQMMP quality assurance procedures included system audits, performance audits of sampling equipment, and participation in the EPA administered National Performance Audit Program (NPAP).

The project quality assurance manager conducted periodic inspections and reviews of the monitoring operation and documentation procedures. Audited operations included sample preparation, installation, removal, reclamation, shipping, and documentation. Observed procedures were compared to those detailed in the project SOPs. Results were reported to project management with recommendations of corrective actions when appropriate. These reports are contained in project files. Also, an independent audit of field and laboratory procedures was performed by Martin Marietta Energy Systems during FY93. Their findings were reported to PMRMA.

Performance audits were performed quarterly on all field samples, including the continuous gaseous analyzer; and semi-annually on the 4 meteorological towers by an independent auditor. All sampler, analyzer, and tower calibrations were tested against standards other than those used to assess operations on a routine basis. For each sampler, the auditor-determined flow rate was compared to the operator-determined flow rate. During FY93, 10 out of 214 samplers audited

Table 7.3-8 Carbon Monoxide Precision Calculations CAQMMP FY1993

Date	Analyzer Response (ppm)	Calibrator Output (ppm)	% Difference	Absolute % Difference
10-14-92	9.0	9.1	-1.1	1.1
10-28-92	9.01	9.68	-6.9	6.9
11-11-92	9.3	9.7	-4.1	4.1
11-11-92	9.04	9.71	-6.9	6.9
11-25-92	8.7	9.7	-10.3	10.3
12-09-92	8.6	9.7	-11.3	11.3
12-23-92	9.2	9.7	-5.2	5.2
01-06-93	9.13	9.7	-5.9	5.9
01-20-93	9.4	9.7	-3.1	3.1
02-03-93	9.7	9.7	0.0	0.0
02-27-93	9.2	9.7	-5.2	5.2
03-10-93	9.4	9.7	-3.1	3.1
03-24-93	9.5	9.7	-2.1	2.1
04-07-93	9.5	9.7	-2.1	2.1
04-21-93	10.5	10.1	4.0	4.0
05-12-93	9.2	10.1	-8.9	8.9
05-12-93	9.5	10.1	-5.9	5.9
05-26-93	9.2	10.1	-8.9	8.9
06-07-93	9.5	10.1	-5.9	5.9
06-07-93	9.6	10.1	-5.0	5.0
06-23-93	9.5	10.1	-5.9	5.9
07-07-93	9.3	10.1	-7.9	7.9
07-21-93	9.9	10.1	-2.0	2.0
08-04-93	9.6	10.1	-5.0	5.0
08-18-93	9.7	10.1	-4.0	4.0
09-02-93	9.7	10.1	-4.0	4.0
09-23-93	10.2	10.1	1.0	1.0
Average % Difference			-4.7	5.0
Standard Deviation			3.4	3.4
Upper 95% Probability Limit			2.1	
Lower 95% Probability Limit			-11.4	

ppm - parts per million
% - Percent

Table 7.3-9 Sulfur Dioxide Precision Calculations CAQMMP FY93

Date	Analyzer Response (ppb)	Calibrator Output (ppb)	% Difference	Absolute % Difference
10-14-92	98.1	93.0	5.5	5.5
10-28-92	92.0	99.4	-7.4	7.4
11-11-92	94.4	99.4	-5.0	5.0
11-16-92	103.5	103.8	-0.3	0.3
11-16-92	92.7	99.4	-6.7	6.7
11-25-92	102.8	103.8	-1.0	1.0
12-09-92	97.04	103.8	-6.5	6.5
12-23-92	100.4	103.8	-3.3	3.3
01-06-93	97.3	103.8	-6.3	6.3
01-19-93	98.1	103.8	-5.5	5.5
01-19-93	99.74	105.7	-5.6	5.6
01-20-93	102.0	105.7	-3.5	3.5
02-04-93	104.7	105.7	-0.9	0.9
02-27-93	99.4	105.7	-6.0	6.0
03-10-93	99.4	105.7	-6.0	6.0
03-24-93	103.7	105.7	-1.9	1.9
04-07-93	100.4	105.7	-5.0	5.0
04-21-93	114.1	115.3	-1.0	1.0
05-12-93	77.5	78.7	-1.5	1.5
05-12-93	75.2	78.7	-4.4	4.4
05-26-93	104.7	101.5	3.2	3.2
06-07-93	100.0	101.5	-1.5	1.5
06-23-93	108.8	108.8	0.0	0.0
07-07-93	112.1	108.8	3.0	3.0
07-21-93	115.1	108.8	5.8	5.8
08-04-93	110.4	108.8	1.5	1.5
08-18-93	112.4	108.8	3.3	3.3
09-02-93	114.2	108.8	5.0	5.0
09-23-93	111.0	108.8	2.0	2.0
Average % difference			-1.7	3.7
Standard deviation			4.0	4.0
Upper 95% probability limit			6.2	
Lower 95% probability limit			-9.7	

ppb - parts per billion
% - Percent

Table 7.3-10 Ozone Precision Calculations CAQMMP FY93

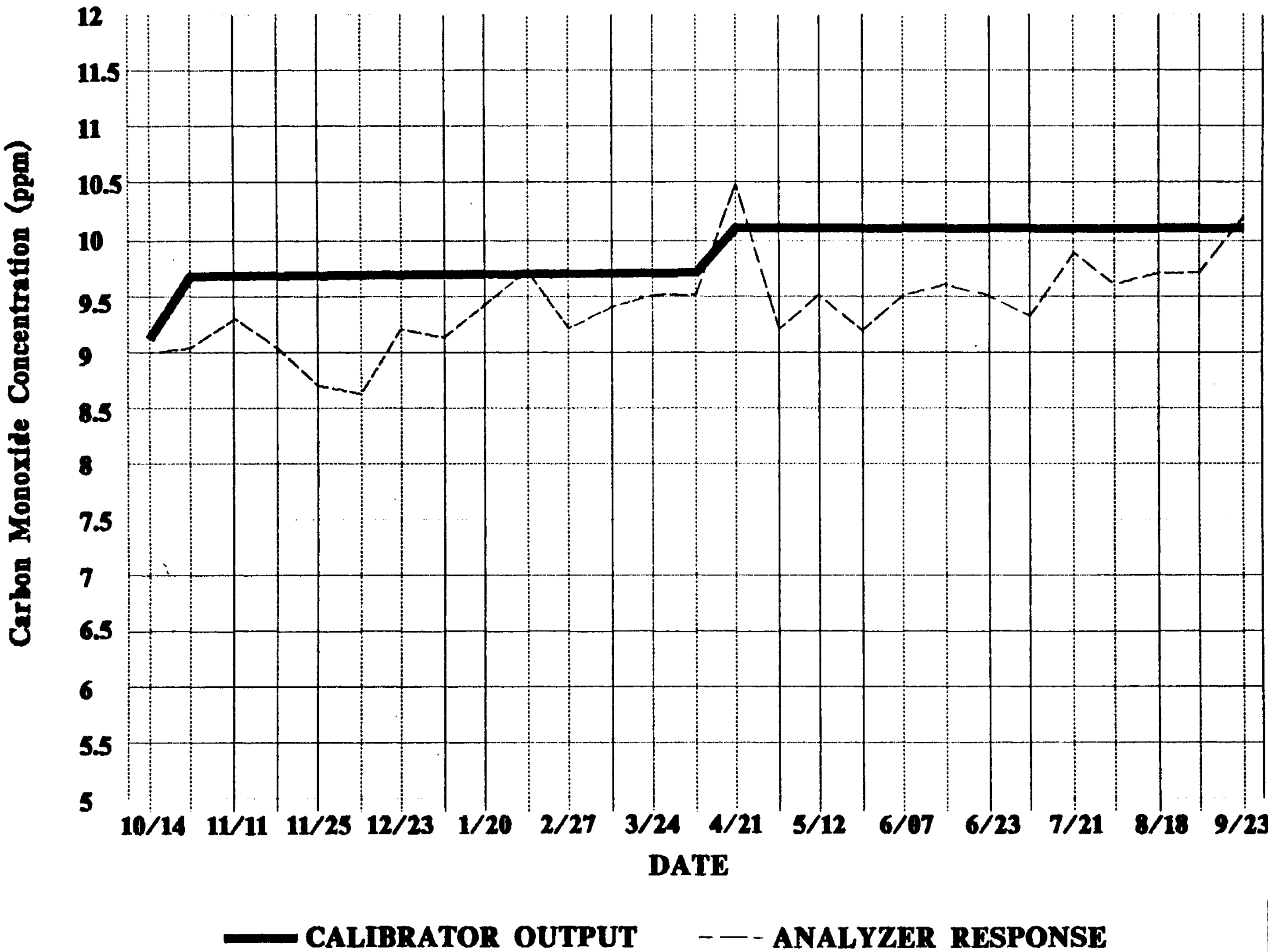
Date	Analyzer Response (ppb)	Calibrator Output (ppb)	% Difference	Absolute % Difference
10-14-92	88.7	89.8	-1.2	1.2
10-28-92	88.5	89.0	-0.6	0.6
11-11-92	89.7	88.8	1.0	1.0
11-25-92	89.3	88.7	0.7	0.7
12-09-92	88.0	88.3	-0.3	0.3
12-23-92	88.5	89.5	-1.1	1.1
01-06-93	89.0	89.0	0.0	0.0
01-20-93	88.8	89.7	-1.0	1.0
02-03-93	86.6	89.0	-2.7	2.7
02-27-93	92.0	89.0	3.4	3.4
03-01-93	75.8	73.7	2.8	2.8
03-10-93	91.9	89.2	3.0	3.0
03-24-93	91.0	89.0	2.2	2.2
04-07-93	89.9	88.7	1.4	1.4
04-21-93	90.3	89.2	1.2	1.2
05-12-93	91.2	89.0	2.5	2.5
05-26-93	90.3	89.5	0.9	0.9
06-07-93	91.3	89.7	1.8	1.8
06-23-93	90.8	89.7	1.2	1.2
07-07-93	90.2	89.0	1.3	1.3
07-21-93	90.1	89.5	0.7	0.7
08-04-93	89.6	89.2	0.4	0.4
08-18-93	94.2	89.0	5.8	5.8
09-02-93	92.5	89.3	3.6	3.6
09-02-93	91.2	90.2	1.1	1.1
09-23-93	91.3	89.5	2.0	2.0
Average % Difference			1.2	1.7
Standard Deviation			1.8	1.8
Upper 95% Probability Limit			4.7	
Lower 95% Probability Limit			-2.4	

ppb - parts per billion
% - Percent

Table 7.3-11 Oxides of Nitrogen Precision Calculations CAQMMP FY1993 Page 1 of 1

Date	Analyzer Response (ppb)	Calibrator Output (ppb)	% Difference	Absolute % Difference
10-14-92	102.5	104	-1.4	1.4
10-28-92	94.7	109.3	-13.4	13.4
11-11-92	102.1	109.3	-6.6	6.6
11-16-92	106.2	102.8	3.3	3.3
11-16-92	97.4	109.3	-10.9	10.9
11-25-92	101.8	102.8	-1.0	1.0
12-09-92	104.8	102.8	1.9	1.9
12-23-92	92.7	102.8	-9.8	9.8
01-06-93	88.3	102.8	-14.1	14.1
01-19-93	101.0	102.8	-1.8	1.8
01-19-93	95.4	105.0	-9.2	9.2
01-20-93	102.4	105.0	-2.5	2.5
02-03-93	107.4	105.0	2.3	2.3
02-04-93	116.2	105.0	10.7	10.7
02-27-93	100.1	105.0	-4.7	4.7
02-27-93	101.1	105.0	-3.7	3.7
03-10-93	99.7	105.0	-5.0	5.0
03-24-93	94.0	105.0	-10.5	10.5
03-31-93	74.9	105.0	-28.7	28.7
03-31-93	93.4	105.0	-11.0	11.0
04-07-93	106.4	105.0	1.3	1.3
04-21-93	118.8	114.5	3.8	3.8
05-12-93	76.9	78.2	-1.7	1.7
05-26-93	101.0	100.8	0.2	0.2
06-07-93	98.7	100.8	-2.1	2.1
06-07-93	99.4	100.8	-1.4	1.4
06-23-93	113.5	108.1	5.0	5.0
07-07-93	116.5	108.1	7.8	7.8
07-21-93	107.4	108.1	-0.6	0.6
08-04-93	107.1	108.1	-0.9	0.9
08-18-93	111.4	108.1	3.1	3.1
09-02-93	113.5	108.1	5.0	5.0
09-23-93	114.0	108.1	5.5	5.5
Average % Difference			-3.7	6.3
Standard Deviation			8.0	7.8
Upper 95% Probability Limit			11.9	
Lower 95% Probability Limit			-19.3	

ppb - parts per billion
% - Percent

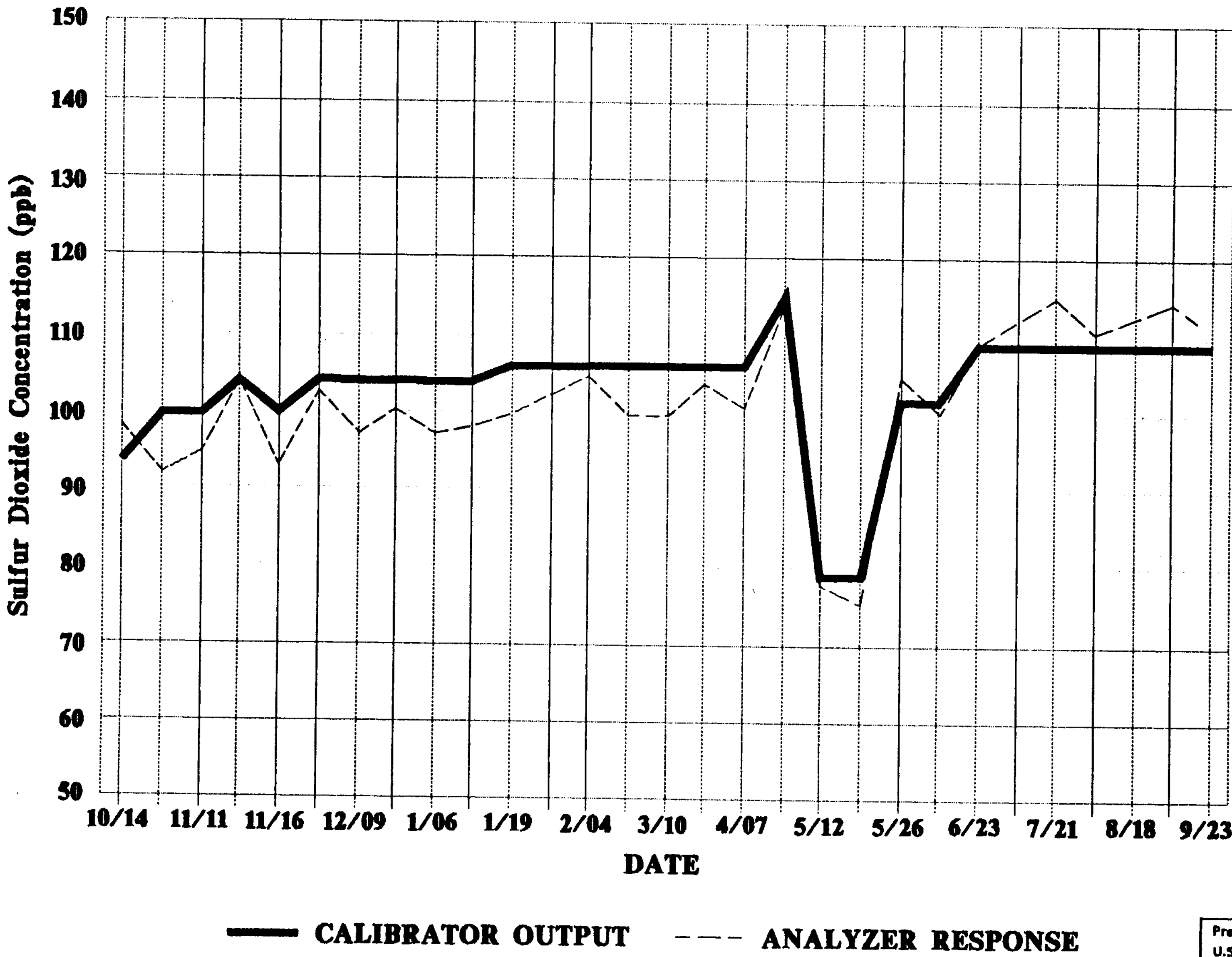


Prepared for:
U.S. Army Program Manager
for Rocky Mountain Arsenal

Figure 7.3-1

FY93 Carbon Monoxide Concentration Precision Checks

Rocky Mountain Arsenal
Prepared by: Ebasco Services Incorporated



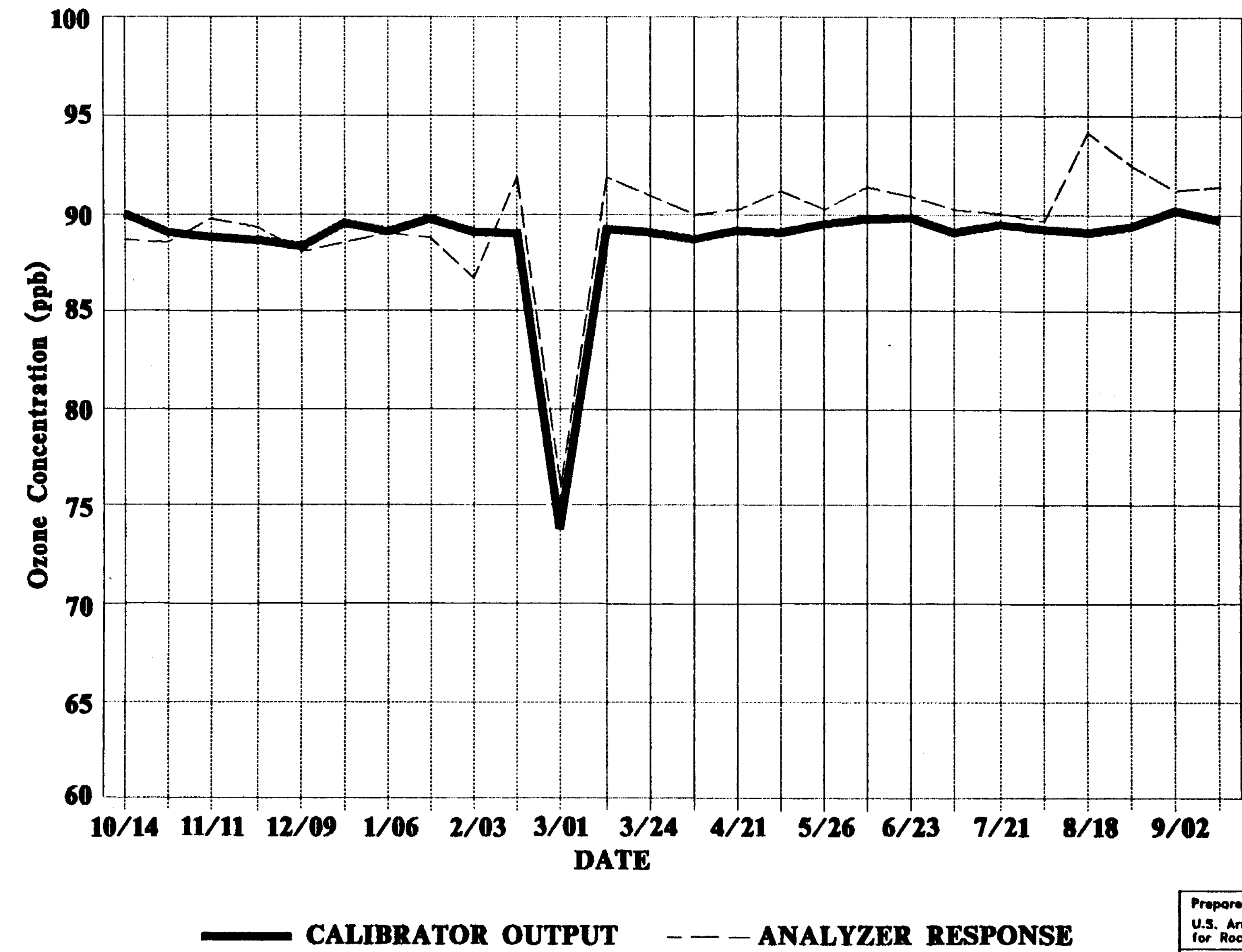
Prepared for:

U.S. Army Program Manager
for Rocky Mountain Arsenal

Figure 7.3-2

FY93 Sulfur Dioxide
Concentration Precision Checks

Rocky Mountain Arsenal
Prepared by: Ebasco Services Incorporated



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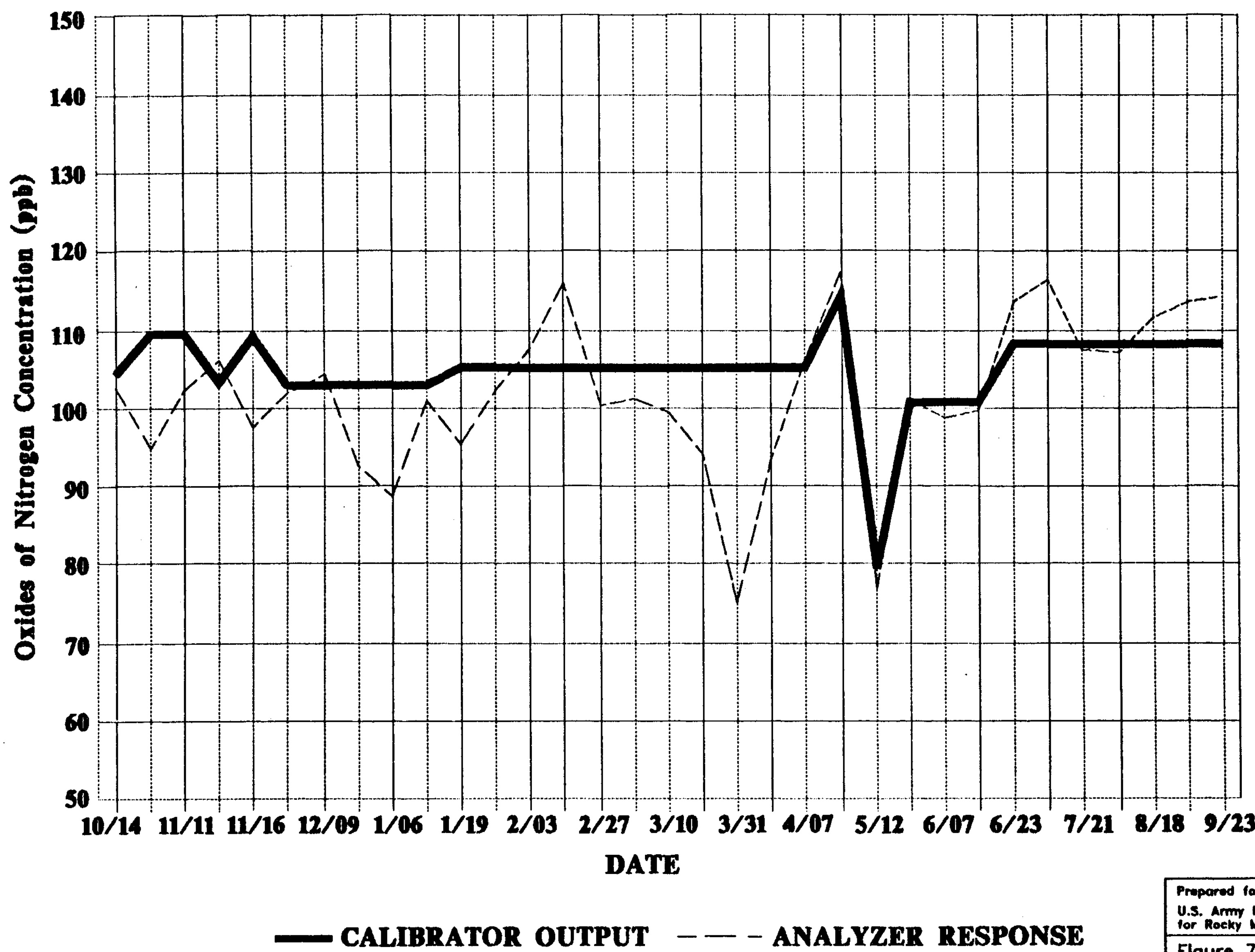
for Rocky Mountain Arsenal

Figure 7.3-3

FY93 Ozone Concentration
Precision Checks

Rocky Mountain Arsenal
Prepared by: Ebasco Services Incorporated



Prepared for:
U.S. Army Program Manager
for Rocky Mountain Arsenal

Figure 7.3-4

FY93 Oxides of Nitrogen Concentration Precision Checks

Rocky Mountain Arsenal
Prepared by: Ebasco Services Incorporated

showed a percent difference greater than ± 7 percent. Field staff were informed of these discrepancies and they immediately performed the required corrective action. These samplers were then rechecked by the auditor as appropriate. Detailed results of all samplers, analyzers, and meteorological towers are provided in the CAQMMP Quarterly Audit Reports. In addition, these reports contain copies of all relevant certification paperwork that documents the traceability of the standards utilized in the CAQMMP.

The CAQMMP voluntarily participated in the NPAP during FY93. The accuracy of reported flow rates for 4 TSP samplers and 4 PM-10 samplers was assessed using EPA-provided test equipment. The CO, SO_2, and NO_x analyzers were checked once and the contract laboratory's lead analysis method was evaluated four times as well. Table 7.3-12 provides the results of these audits. All results were well within EPA prescribed tolerances.

7.3.5 Data Processing

A series of formal steps was implemented to ensure the quality of data generated under the CAQMMP. All field data sheets, calibration forms, and chain of custody forms were reviewed and double-checked by the field team. The project data management coordinator reviewed these files and provided PMRMA's contract data processing group (D.P. Associates) with calculated sample volumes. For each sample, the laboratory provided a raw weight for each target analyte. These values were entered into the IRDMIS system where method accuracy corrections were applied and sample concentrations calculated. Project chemists reviewed the associated laboratory quality control data; including surrogate and spiked recoveries and general compliance with PMRMA quality control methodology. The acceptability of each lot was addressed by the laboratory and reviewed along with control charts by the project QA team and PMRMA. Periodic checks of the IRDMIS air quality database were made by the project data management coordinator to verify sample identifications and concentration calculations.

Table 7.3-12 FY93 National Performance Audit Program

Type	Date	CAQMMP Reported Result	EPA Reported Result	% Difference	Comment
Lead (μg)	1/15/93	700.00	703.00	-0.4	
		194.00	200.00	-3.0	
	4/5/93	972.00	954.00	1.9	
		96.80	100.00	-3.2	
	7/9/93	847.00	869.00	-2.5	
		236.00	251.00	-6.0	
	10/25/93	645.00	615.00	4.9	
		153.00	148.00	3.4	
Hi Vols	2/5/93	1.126	1.129	-0.3	AQ1 PM-10
($\mu g/m^3$)		1.150	1.129	1.9	AQ4 PM-10
		1.130	1.148	-1.6	AQ1 TSP
		1.131	1.160	-2.5	AQ4 TSP
	7/27/93	1.108	1.113	-0.4	SQ1 PM-10
		1.172	1.185	-1.1	SQ2 PM-10
		1.084	1.153	-6.0	SQ1 TSP
		1.170	1.180	-0.8	SQ2 TSP
Analyzers	7/12/93				
CO				3.75	Mean % Diff.
SO_2				0.55	Mean % Diff.
NO_2				7.92	Mean % Diff.

PM-10 - Particulate matter less than 10 micrometers
TSP - Total Suspended Particulates
Diff. - Difference
CO - Carbon monoxide
SO_2 - Sulfur dioxide
NO_2 - Nitrogen oxides
% - Percent
μg - Micrograms
$\mu g/m^3$ - Micrograms per cubic meter
Diff. - Difference

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